STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

HEARINGS

BEFORE THE

SPECIAL SUBCOMMITTEE ON MINERALS, MATERIALS, AND FUELS ECONOMICS

OF THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE

EIGHTY-THIRD CONGRESS

FIRST AND SECOND SESSIONS

PURSUANT TO

S. Res. 143

A RESOLUTION TO INVESTIGATE THE ACCESSIBILITY AND AVAILABILITY OF SUPPLIES OF CRITICAL RAW MATERIALS

PART 8

TITANIUM

HENDERSON, NEV., SEPTEMBER 28 AND 29, 1953

LOS ANGELES, CALIF., NOVEMBER 3 AND 4, 1953

WASHINGTON, D. C., NOVEMBER 23, 24, 25, 27, 1953, JANUARY 28, FEBRUARY 1, AND APRIL 7, 1954

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STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

MONDAY, SEPTEMBER 28, 1953

UNITED STATES SENATE,
SPECIAL SUBCOMMITTEE ON MINERALS,
MATERIALS, AND FUELS ECONOMICS OF THE
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Henderson, Nev.

The Minerals, Materials, and Fuels Economic Subcommittee met, pursuant to notice, at 10 a. m., in the Colorado River Commission Conference Room, Henderson, Nev., Senator George W. Malone (chairman of the subcommittee) presiding.

Present: Jerome S. Adlerman, counsel to subcommittee; George R. Holderer, staff engineer to subcommittee; A. M. Smith, administrative assistant to Senator Malone.

Also present:

For the Air Force: Brig. Gen. Kern B. Metzger, Chief, Production Resources Division, Air Matériel Command, United States Air Force, and Director of the Aircraft Production Resources Agency of the Department of Defense; Col. H. G. Macdonald, USAF, assistant to General Metzger for production; Capt. Joseph L. Dodson, United States Navy, Aircraft Production Resources Agency, WPAFB, Ohio; Lt. Col. D. A. Simcoe, Jr., Air Matériel Command, United States Air Force.

For the Colorado River Commission: A. E. Cahlan, acting chairman; A. E. Suverkrup, executive assistant to Gov. Charles H. Russell; Don Ashbaugh, secretary; C. F. Neumann, engineer; C. A. Baumert, county engineer; J. H. Buehler, member; Frank Strong, member; H. R. Rowland, member, Reno, Nev.

For the United States Bureau of Mines, Boulder City, Nev.: Rex R. Lloyd, Director; F. S. Wartman, Chief, Titanium Research Section; M. G. Mastin, Section Head, Titanium Development Section.

For the titanium industry: R. P. Smith, plant manager, Titanium Metal Corporation of America, Henderson, Nev.; F. J. Shirley, assistant manager of titanium division of National Lead Co., Henderson, Nev.; E. M. Richards, vice president, Republic Steel, in charge of planning and development, Cleveland, Ohio; James A. Roemer, president, Malloy-Sharon Titanium Co., Niles, Ohio; F. H. Vandenburg, vice president and general manager, Malloy-Sharon Titnium Co., Niles, Ohio; Fred Lohse, assistant to vice president, Kaiser Aluminum & Chemical Corp., Oakland, Calif.; Jack Lane, American Pipe & Steel Corp., Alhambra, Calif.; S. Krentz, Combined Metals Production Co., manager, Nevada operation, Henderson, Nev.; S. J. McCarroll, general superintendent, Manganese, Inc., Henderson, Nev.; Roy Martindale, power consultant, Stauffer Chemical Co., Henderson,

Nev.; F. W. Wayfs, attorney, Stauffer Chemical Co., Henderson, Nev.; Arthur Newell, works manager, Stauffer Chemical Co., Henderson, Nev.; R. P. Feist, division manager, California Pacific Utilities Co., Henderson, Nev.; Julian Moore, secretary, Basic Management Co., Inc.; W. B. Mainor, superintendent, U. S. Lime Products Co.; R. W. Lockridge, plant manager, Pioche Manganese Co., Pioche, Nev.

PROCEEDINGS

Senator MALONE. The subcommittee will be in order.

Senate Resolution No. 143 authorizes and directs the Senate Committee on Interior and Insular Affairs (1) to make a full and complete investigation and study of the accessibility of critical raw materials to the United States during a time of war; (2) to study and recommend methods of encouraging developments to assure the availability of supplies of such critical raw materials adequate for the expanding economy and the security of the United States.

The Minerals, Materials, and Fuels Economic Subcommittee has been engaged for some time on a preliminary investigation into the production and uses of titanium. These studies show that it is urgent that full-scale hearings be held so that the subject of titanium, its production and use can be examined in detail.

Titanium is a must for superior air power in the future. Its use in high-speed, sonic and above sonic planes is essential and, considering the weight-strength ratio, there is no other known metal that is so uniquely fitted for the construction of a major part of airframes and engines. It has been described as a wonder metal because of its exceptional qualities of light weight and heat resistance. It is as strong as steel with the lightness of aluminum. It is nonmagnetic corrosion resistant and can withstand high temperatures which melt aluminum.

A titanium shortage poses a major threat to the United States air power position. The United States cannot afford to have the second best air force. As a matter of fact in time of war there is no such thing as a second best air force. If any enemy possesses planes incorporating titanium, and if the United States does not have planes of equal light weight strength, speed, maneuverability and range we will be defeated in the air. Such defeat would be fatal to the Nation. The United States simply cannot afford to be without titanium. Our pilots are entitled to an even break.

There have been disquieting rumors that Russia has been working on the production of titanium. A check of the bibliography on titanium shows that since 1934 Russia has exhibited an undue interest in titanium as evidenced by the number of articles written by Russian metallurgists and scientists. It is also a well-known fact that some of the best-known German scientific brains have been working with the Russians, either as willing or captive scientists.

We have even received information that some of the titanium metal may have been exported to countries behind the Iron Curtain.

I am disturbed that there has been an undue delay in the development of titanium production in the last 3 or 4 years and it is my hope that by throwing the searchlight of publicity on the subject and bringing it to the attention of the proper authorities we will overcome the inertia and get titanium into full-scale production.

From what I have learned of the metal thus far I feel that it may well revolutionize aircraft design and construction to bring about planes of enormous high-speed maneuverability and range, which because of the lightness and ability to withstand high heat will be able to carry larger payloads of military equipment, armament, and provide increased speed or range which will make our present-day planes obsolete and inadequate.

It is my considered opinion that the production of titanium in the future may well revolutionize not only aircraft but all types of military equipment. Its strength, lightweight characteristics, nonmagnetic qualities, will be a tremendous advantage in its use in tanks, artillery, shell cases, machineguns, mortars and other mobile weapons. The pack load of a foot soldier could be reduced 50 to 60 percent if titanium were used in place of heavy metals of equal strength. An enormous increase in the use of titanium will take place in the commercial field as the qualities of the metal are better understood and it becomes available at a lower cost.

The use of this wonder metal in commercial planes could increase the "payload" up to thirty percent or more.

It is the intention of the committee to do everything within its power to obtain increased production at as early a date as possible and to remove any obstructions to such program.

The proper utilization of this metal will provide an added deterrent to war—and could well develop into a major new peacetime industry in the stabilization and growth of our economy.

Now however, there are at least three companies in the business of producing titanium or about to get into the business, about which General Metzger will speak. I consider him the outstanding authority in this field, both as to the present status of the production and the present need for the metal, and also as to the future needs and uses of titanium.

It has many properties, some of which are classified. It is approximately twice as strong as aluminum per pound, and therefore has a tremendous future use in airborne equipment, airplanes—in fact, any movable equipment, in the opinion of the chairman, so it is therefore very important at this time.

There is another factor which must be considered in the manufacture of titanium by the process now used, and that is the power supply in any area where it is being manufactured, or where an increase in manufacture is being contemplated.

Now, General Metzger, will you identify yourself for the record, please?

TESTIMONY OF GEN. KERN D. METZGER, UNITED STATES AIR FORCE

General METZGER. United States Air Force, Chief, Production and Resources Division, Air Materiel Command; and Director of the Aircraft Production Resources Agency.

Senator MALONE. I have looked forward with pleasure to having you appear before the committee, because I have long considered you one of the outstanding experts in this field. In your position as head of the Dayton Air Field where equipment tests are made and many of

the plans for future air equipment are formulated. I consider your knowledge of this question perhaps greater than that of any one man.

If you will, then, in your own way make any statement you care to at this time. The reporters understand that your testimony will not be of a classified nature, because the general will withhold any classified information until later.

General, will you proceed.

General METZGER. Thank you, Senator Malone.

The Air Force first became seriously interested in titanium about 3 short years ago, because up until that time, as you so well put it, titanium was almost unknown in metallic form. It does possess an unusual combination of intrinsic properties and it has become, in our opinion, a very important structural metal.

The production problems are being mastered with rather amazing rapidity, so that within a short period of time it is possible that titanium metal will overrun magnesium in tonnage output.

Senator MALONE. How does titanium, not to interrupt your line of thought, but how does titanium production compare with the beginning of magnesium production?

For example, the use of magnesium at the start of its production was also limited?

General METZGER. Well, it is going through the same pattern, the same growing pains, and the pattern costwise is rather uniform.

In fact, titanium in its growth is following the same pattern as aluminum and even stainless steel.

Senator MALONE. In other words, it was years after the discovery until the volume of manufacture could get the price down to where it was really available.

General METZGER. That is correct; and also years before industry was able to employ and use the materials in the manner they are presently being used.

The know-how to be gained in the use of titanium is no different than the know-how that has to be developed in the use of aluminum, magnesium or stainless steel. I am referring principally to aircraft equipment.

Senator MALONE. General, I hope that you will not omit any of the details because you understand them so well it may be that you might assume other people know more about this matter than they actually do. In your explanation make it detailed enough so that men not technically trained may understand the importance, the present use, and the future possibilities of titanium.

Of course, designers and manufacturers are unable to plan on the use of any material until they know it is going to be available. It seems that we are in a position now with respect to titanium, similar to our past positions with regard to other metals. Its uses will necessitate production at a rate many times in excess of present production but until its availability is assured, manufacturers do not dare change designs; is that right?

PROBLEMS TO MEET

General METZGER. That is correct. We in the Air Force, charged with the responsibility of approving design which incorporates materials and metals must be certain that we, to the best of our ability,

know that the materials and the metals are approved by the Air Force and will be available to support the production schedules, not only that we have present procured, but also support schedules which might be called upon in the event of a mobilization effort.

So we have a very great problem in titanium. We have had the same problem in aluminum and magnesium.

With the problems and experience behind us in World War II, we certainly would be remiss if we didn't take the necessary steps at this time in dealing with a new metal such as titanium, to employ it in our weapons in an orderly manner and in consonance with the availability of the material.

The Air Force is interested in titanium for two principal reasons.

No. 1, we believe that this is a metal which can be produced without offshore support. In other words, on the North American Continent there are sufficient ores, in our opinion, to provide not only all the titanium that we can foresee use for and need of at this point, but all that we would need in the event of a mobilization effort, which effort could be supported by the industrial structure of the country.

Senator MALONE. Let me ask you at this point, General, it has been said that the raw material from which titanium is manufactured is the fourth most abundant metallic element in the earth's surface. Of course, the concentration of the material is also very important.

I just understood you to say that you believe the United States and the Western Hemisphere can be made self-sufficient in the raw material production from which this metal is manufactured?

General METZGER. Senator Malone, we believe that.

Senator MALONE. And that raw material in the United States is ilmenite?

General METZGER. Yes, sir.

Senator MALONE. Where are we securing the raw material now?

General METZGER. It is being imported from Australia in some little supply, perhaps furnished from the sands and the shores. In this country it comes from the sands and shores in Florida, Georgia and rutile is also known to exist in the sands and the coastline of California.

I believe the ore which is presently in use is nearly all imported from Australia.

Senator MALONE. The interest of the committee in your testimony on that point is very great because we are directed to determine the availability of the minerals, materials and fuels in time of war. Many military strategists believe that it will be almost impossible to send surface freight ships across either ocean when world war IV, or whatever they choose to call it in point of numbers, starts.

Wouldn't it be a good idea—at the same time we are importing rutile ore from Australia and perhaps elsewhere—to start eliminating the bugs from commercial production methods for the treatment of ilmenite ore, found in the United States and in the Western Hemisphere?

General METZGER. We believe that is highly desirable, and no doubt some research and development work has been under way by the present producers for some time in the utilization of ilmenite and in lieu of rutile. Just to what extent I am not too sure of at this point.

Senator MALONE. I think we may be able to develop that part of it from the actual producers who will be heard later.

General METZGER. Yes, sir; that is of No. 1 interest to the Air Force.

Senator MALONE. What are some of the particular attractive characteristics of titanium?

General METZGER. To military aircraft, the favorable strength-rate ratio at elevated temperatures of titanium is very attractive.

As is well known, military aircraft and the utilization of military aircraft as weapons for defense depend upon characteristics such as speed, maneuverability, and range. Those characteristics in military aircraft are in direct proportion to the weight of the aircraft structure.

As we design newer, faster high-flying aircraft we run into temperatures which—it is just axiomatic that temperatures increase with speed and height, and we must employ in structures and on surfaces of those aircraft materials which presently are unknown, do not exist to our knowledge other than titanium.

Touching a moment upon the range of the aircraft, obviously the payload, which is fuel, ammunition, and bombs in military aircraft, our capability along those lines to carry those products is in direct proportion to the weight of the aircraft dry.

So as we produce lighter aircraft, still with the same strength and structural integrity, we look toward materials and metals such as titanium.

Senator MALONE. You look toward titanium to solve your problems for engines particularly, but also for airframes?

General METZGER. Yes, sir.

Senator MALONE. For example, zirconium in your engines, you suddenly needed some greater heat-resistance material in your jet engines and zirconium answered part of the problem?

General METZGER. Yes.

Senator MALONE. And that is another one of the metals that this committee is greatly interested in.

General METZGER. Yes. Titanium in a jet engine answers the problems, and it pays off tremendously in the reduced weight of that engine.

I will not mention the engine by model or type, but we can take one combat aircraft today and with engineering complete with the use of titanium for that engine we can save 500 pounds per engine; on a 4-engine aircraft, that is 2,000 pounds.

Roughly that conversion could increase the speed of that aircraft 15 knots, or increase the range of that aircraft 100 miles.

Senator MALONE. Through the additional fuel the plane can carry due to decrease in weight of the plane?

General METZGER. Through the additional fuel they can carry and the additional speed due to the lighter weight. That is just an engine application to a presently developed in—production aircraft.

If that application had been available—or those applications, because there are many parts in the cold end of this particular engine which will be changed over—had that been possible at the time the airframe was designed, a far greater saving and a far greater military advantage would have been gained because the rule of the thumb in

aircraft production and manufacture is that 1 pound of deadweight removed from an aircraft permits the reduction of 10 pounds of structural weight in design.

Senator MALONE. Well, why was it that you were unable to design the frame so as to use titanium?

General METZGER. Well, it takes, Senator Malone, years to develop an aircraft. It takes for a heavy bomber, I would say, about 5 years from the drawing board to the production of the article.

So the aircraft we are talking about was theoretically built about 4 or 5 years ago. At that time titanium was unknown, the characteristics and terrific properties were not known.

Senator MALONE. And there was practically no titanium available?

General METZGER. And there was no titanium available.

MUST BE CERTAIN OF SUPPLY

Senator MALONE. What would you dare do in anticipation of the use of titanium in airplanes now on the drafting table?

General METZGER. We must be certain that titanium will be available in quantity and in quality to support the production of those aircraft 3, 4, or 5 years hence. It can be recognized that if we employ titanium, as I mentioned before, to its ultimate advantage and design the structure of the aircraft itself around titanium in various equipments, that it would be a very costly, if not impossible, situation to convert back in the event titanium were not available.

So we must pursue this with extreme caution, and we are. We are actually today allocating the available titanium supplies to current aircraft, and we have established an Air Force regulation wherein we approve the use of titanium for aircraft in design prior to the approval being given to the aircraft manufacturers to go ahead and design it in.

As I touched upon earlier, it could be very serious in the defense of this country if we were to tie ourselves to a highly desirable material such as titanium in strategic aircraft, and then be unable to build the aircraft. We must not permit that to happen. That is constantly before us.

Senator MALONE. Then I understand from your statement, General, that right at the moment you are holding back any plans to use titanium in the design of future airplanes because of the lack of assurance that this metal will be available in the quantities necessary?

General METZGER. Not only, Senator Malone, are we holding back—answering your question directly, yes, sir, we are—but still of greater importance I believe and of more serious nature the aircraft designer himself is holding back.

We do not in the Air Force design aircraft. We work with our manufacturers; we approve designs; we approve all engineering changes, but the basic responsibility for design rests with the aircraft industry, or the aeronautical industry, if it is equipment we are talking about.

The inability of the aeronautical industry to secure titanium mill products of quality, of acceptable quality, and in quantities, and in point of time required has discouraged what we feel would be the normal advancement in the use of titanium.

Senator MALONE. In other words, if I understand you correctly, you do not design the planes but you lay down the specifications as to what the planes should do?

General METZGER. Yes.

Senator MALONE. And you ask for designs of planes which will perform according to your specifications?

General METZGER. Yes, sir; aircraft are bought on a competitive basis, based upon basic specifications.

Senator MALONE. Performance?

General METZGER. Performance evaluations are taken prior to the placement of these contracts or the awarding of the contract to any one particular manufacturer.

The manufacturer would undertake to produce an aircraft, for example, to conform to the specifications which we have established, and those specifications generally relate to the mission to which that aircraft would be assigned.

Senator MALONE. Well, the lack of assurance that this metal would be available prevents the designers from anticipating the use of titanium in any design they furnish you at the present time?

General METZGER. I would think so. I certainly have the greatest confidence and respect in the world for the integrity of the aeronautical industry, and I am sure that integrity of industry would demand that industry design within their knowledge of the capabilities of the material to support the design.

I do not believe that the American industry would sell the Government down the road. It is just normal, therefore, that they proceed with caution as do we proceed with caution in approving.

Senator MALONE. But their caution now is dependent upon the available supply? You know what it will do when you get it?

General METZGER. We know many things it will do. We don't know all about it. But we know many things it will do and we know at this point that there are aircraft fairly well along in design that we need, the country needs to maintain or achieve air superiority, and which must use titanium in substantial quantities.

UNITED STATES NOT ONLY PRODUCER

Senator MALONE. It is not anticipated or believed that we are the only nation which knows how to make titanium, is it?

General METZGER. No, sir; we are not.

Titanium, and good titanium, as far as reports given us are concerned, is being produced in Japan.

Senator MALONE. Are we buying any of it?

General METZGER. We ourselves are not, but the industry is buying Japanese titanium, sponge, in what quantities we don't know. We understand that one or two of the companies have negotiated with Japanese sources for the output of the Japanese plants.

Senator MALONE. What is the price? Do you know how it compares to the price at which we are able to produce titanium?

General METZGER. I heard, Senator Malone, that it could be laid down in this country for a fraction less than the cost, than the selling price of titanium produced in this country. I don't know whether that situation exists now or not.

That may have been the situation when the Japanese were trying to sell it. The price will change with the demand. I am sure the Senator knows that.

Senator MALONE. This is probably not the last of your appearances before the committee, and perhaps in the interim you may find out more about this particular production.

Isn't it a fact that we are buying some titanium from England?

General METZGER. I am not aware that we are buying from England. We are selling titanium to England, I understand.

Senator MALONE. They do produce titanium in England, do they not?

General METZGER. Not that I know of in any great quantity; not in production quantities that I know of.

MUST KEEP PACE

Senator MALONE. Well, the facts are that if we do not keep pace in our production of titanium for our airplanes, bombers and fighters and military airplanes, other nations which might be potential enemies could get the jump on us in the production of this vital material. That is a potential danger, is it not?

General METZGER. Yes, sir, very definite danger. The danger being that our aircraft will not be competitive with the aircraft of our enemies, Senator Malone.

Senator MALONE. As a matter of fact, our aircraft would be obsolete if they were not constructed out of this new metal?

General METZGER. That is a very blunt way of presenting it, Senator Malone, and I agree.

Senator MALONE. And some of us are very much afraid we are manufacturing some obsolete equipment now.

Could you give me, for the benefit of the record, General, what is the present production and the projected supply of this metal right at the present time?

General METZGER. It might be interesting. Senator Malone, if in answering that question and if you will permit to give just a little background of the supply picture.

Senator MALONE. I would like it if you would, for the benefit of the committee.

General METZGER. Yes, sir. In 1952, the Department of Defense requested DMPA, Defense Minerals Procurement Agency——

Senator MALONE. Spell out what these names means. I have always intended to introduce a bill to make it a penitentiary offense to use initials.

General METZGER. That would be very appropriate, Senator Malone.

Senator MALONE. Washington streets are paved with them, and everyone is confused.

General METZGER. The Department of Defense requested Defense Mineral Procurement Agency to provide for titanium sponge capacity of 35,000 tons per year by 1956.

That request of the Department of Defense was based upon requirements furnished by the three military departments.

35,000 TONS REQUESTED

General METZGER. The 35,000 tons requested by the Department of Defense resulted in an expansion program certified to reach 22,000 tons per year in 1956.

Senator MALONE. I thought you said 35,000?

General METZGER. 35,000 tons was requested by the Department of Defense.

It resulted in a certified expansion program of 22,000 tons. Of that 22,000 tons, 13,000 tons per year are on contract.

When I say "on contract" there are three manufacturers, Titanium Metals Corp., Du Pont, and Cramet, which is the Crane Co.

Senator MALONE. The last contract was a recent one?

General METZGER. Yes, sir; that is the most recent.

The contracts which are, in substance, underwritten as to capital expenditures by those companies, by the Government; that is, the Government agreed to purchase in certain quantities per year at a certain price.

Senator MALONE. Did I understand you to say 32,000 tons per year?

General METZGER. 22,000 tons per year.

Senator MALONE. 22,000 tons per year have been certified. Of that amount how much is under contract?

General METZGER. There are 13,200 tons under contract at this time; 8,800 tons, to be exact, uncontracted balance.

The capacity at du Pont, when the expansion program is complete, should approximate 3,600 tons per year.

Senator MALONE. How much are they producing at the present time?

General METZGER. I would say 1,650 tons per year.

Senator MALONE. A little less than one-half, about 40 percent.

General METZGER. Yes, sir. Titanium Metals should have the same capabilities, 3,600 tons per year. Their production at this point is fluctuating, and I would prefer that they state their projected capability.

Senator MALONE. What are they producing at this time?

General METZGER. Well, it is fluctuating so that I believe inacceptable—this was sponge production I was talking about——

Senator MALONE. 3,600 tons of sponge?

General METZGER. Yes, sir; that would be about 700 tons from Titanium Metals Corp. in the fourth quarter of this year, which would be 2,100 tons on an annual basis.

Senator MALONE. This is sponge?

General METZGER. Yes.

Senator MALONE. For the benefit of the reporter, the figures you have been giving have been sponge?

General METZGER. Yes, sir.

Senator MALONE. The projected and the actual?

General METZGER. Yes, sir.

Senator MALONE. What was the figure that you gave for the total production in 1953 for the Titanium Corp.?

General METZGER. For 1953, well, this 400 tons in the fourth quarter—well, 700 tons in the fourth quarter exceeds the production in the first three quarters of this year.

Senator MALONE. What was the sponge production in the first three quarters?

General METZGER. I don't have those figures. I believe Titanium Corp. could furnish them more accurately than I, but I would say not to exceed 500 tons a quarter of sponge. From January to June, Titanium Metals, we estimate 132 tons.

Senator MALONE. Of sponge?

General METZGER. Yes, sir. June to December, we estimated 192 tons.

Senator MALONE. Are you talking about sponge?

General METZGER. Yes, sir. That is 1952.

Senator MALONE. From June to December, how much?

General METZGER. July to December, 192 tons.

Senator MALONE. That made 324 tons in 1952?

General METZGER. 324 tons.

Senator MALONE. In 1953, what was the actual production for the first three quarters?

General METZGER. For the first 6 months of 1953, it was 509 tons of sponge. For the last half of 1953, we estimate 1,500 tons.

That makes a total actual and estimated for the year of 1953, of 2,009 tons of sponge from Titanium Metals Corp.

Senator MALONE. It appears that would be a very satisfactory increase?

General METZGER. Yes, sir; the improvement is good although the production is somewhat behind schedule, and the order board of the company, as we know it, shows a considerable backlog resulting from inability to deliver or to comply with original delivery promises.

Senator MALONE. What were the requirements for titanium as compared to production in 1953?

General METZGER. Well, in 1953, the total requirements are estimated at 3,421 tons; total estimated supply, 2,450 tons.

Senator MALONE. That is requirements compared to what they will deliver?

General METZGER. Yes, sir.

Senator MALONE. I thought it added up to 2,009 tons.

General METZGER. I am putting in here TMC.

Senator MALONE. You mean Titanium Metals?

General METZGER. Yes, sir; we estimated that at 2,009 tons.

Senator MALONE. I thought that was sponge.

General METZGER. Yes, sir; that is right; sponge.

DEFICIT IN 1953

Senator MALONE. And that is Titanium Metals?

General METZGER. We are talking about three producers at present, DuPont, Titanium Metals Corp., and the United States Bureau of Mines.

Senator MALONE. They are the only three producers at this moment?

General METZGER. Yes, sir.

Senator MALONE. The Crane Co., what do you call it?

General METZGER. Cramet.

Senator MALONE. We will get to that later.

General METZGER. Yes, sir. We show a deficit of 971 tons of titanium sponge in 1953.

Senator MALONE. You are still talking about the Titanium Corp?

General METZGER. That is total requirements as against total availability.

Senator MALONE. But from the three sources you estimate 971 tons short of the total expectancy in 1953?

General METZGER. Not the total expectancy, the total requirements short of satisfying Department of Defense requirements in 1953 is 971 tons.

Senator MALONE. Then to complete the record, what part of this deficit is chargeable to the Titanium Corp?

General METZGER. Well, we had hoped that Titanium Metals would reach, would more closely approximate their capability of 10 tons a day, or 3,600 tons a year in 1953, more closely approximate or reach it than they have.

Senator MALONE. Well, this is sponge?

General METZGER. Yes, sir.

Senator MALONE. What is the actual production as of today?

General METZGER. In sponge?

Senator MALONE. Yes.

General METZGER. For the year 1953? Do you want Titanium Metals or the total?

Senator MALONE. We are now considering the Titanium Metals Corp.

General METZGER. The actual production today for the first 6 months of 1953 from Titanum Metals Corp., according to our reports, is 509 tons.

Senator MALONE. How much is that per day? That would be 180 divided into 509.

General METZGER. It is a little under 3 tons per day.

Senator MALONE. Right at the moment that is where we are? There will probably be some increase to 3 or 4 tons a day, would you say?

General METZGER. 700 tons for the fourth quarter would be a substantial increase.

Senator MALONE. Well, there is 1 month gone on the fourth quarter. Has production stepped up so you can count on the 700 tons?

General METZGER. We don't have the forecast by months. Our only forecast is for the 4 quarters.

Senator MALONE. And that would be 700 tons for the fourth quarter?

General METZGER. Of sponge; yes, sir.

Senator MALONE. That is about 4 tons a day?

General METZGER. Yes, sir.

Senator MALONE. A little less than 4 tons per day. What is the estimate for next year?

General METZGER. The estimate is the achievement of the 10-ton-a-day rated capacity of the plant, or 3,600 tons a year in 1954.

Senator MALONE. Do we reach that rate of production immediately after the first of the year?

General METZGER. No, I don't say we will. There are certain technical difficulties and quality problems, quality of the product, which Titanium Metals Corp. have been confronted with from the beginning.

Senator MALONE. Off the record a moment.

(Discussion off the record.)

Senator MALONE. On the record.

General METZGER. As I was mentioning, the forecast of the capability of Titanium Metals Corp. to reach the rated plant capacity, it depends entirely upon their ability to solve some of the technical problems which have affected their production and have affected the quality.

Senator MALONE. What are some of these problems in general?

General METZGER. We are not familiar with that at all, Senator Malone. I feel that Titanium Metals are well qualified to answer that.

Senator MALONE. You do know something about the product itself, though. What does the product that you are getting now lack to make it usable?

General METZGER. Well, the sponge has been too hard. The Brinnell hardness has exceeded the specifications required for aircraft use in many instances.

Senator MALONE. Could you give us those specifications just for the benefit of the record?

General METZGER. Well, again I would like to qualify this to the extent that our manufacturers employing or using the mill product may be able to use metal which exceeds the specified Brinnell limits, but it is a costly proposition for the manufacturers to use it in that manner and it is rather discouraging.

Every attempt is being made by all the producers, by both Titanium Metals and Cramet and the Bureau of Mines, to conform to the limits which have been established.

Senator MALONE. What are those limits?

General METZGER. Those limits for alloy sheet would be 150 or below Brinnell hardness and for ingot stock 180 Brinnell.

I don't know as to Titanium Metals—Mr. Ronnie Smith may know, I am sure he knows—just what proportion of his production is exceeding these specifications, and therefore not acceptable for conversion to ingot by Titanium Metals for aircraft use.

Senator MALONE. Material of a hardness higher than the set limits is unacceptable because it is hard to roll evenly and produce the sheet metal?

General METZGER. That and its strength characteristics. It doesn't have the ductility required; it doesn't work as it should work as is required to produce our equipment, or it doesn't have the strength characteristics essential for the application of it.

Senator MALONE. Then, as a matter of fact, you are only getting a small amount of metal which meets the set limits and is usable?

General METZGER. Well, these figures which I gave were production figures as we know them of acceptable quality sponge.

Senator MALONE. That is what I mean.

General METZGER. How much more sponge was produced which didn't meet the specifications and was disposed of in some other manner we don't know.

Senator MALONE. But the figures you gave for the record are the acceptable grades?

General METZGER. Yes, sir.

Senator MALONE. Let me ask you, General, when you let a contract to these companies are they confined to one process in making titanium or are they allowed to use any other processs that would produce the required grade?

RESEARCH IMPORTANT

General METZGER. Well, the contracts were let through General Services' Administration, certified by DMPA. I have given the correct term before on that. They were generally based, so we understand it, on one method.

It was more or less necessary for each company in securing its contract from the Government to prove that it had operated a successful process, and that process in common use and recognized as an acceptable process is the Kroll process.

Continuing research and development on the part and at the expense of each company is highly desirable and it is undoubtedly under way. That is research and development into continuous production processes rather than the process of the Kroll method.

Senator MALONE. Will you explain that further? Is the Kroll method confined to the batch process?

General METZGER. Pretty generally accepted as a batch process, yes, sir.

Senator MALONE. And the Kroll process is not adaptable to a continuous process?

General METZGER. Not as a continuous process is generally defined and interpreted, no, sir.

Senator MALONE. Now, particularly are the contractors confined to the Kroll process? If they met the specifications would it make any difference to the Government how they manufactured it?

General METZGER. No, sir, it would not.

Senator MALONE. So, as a matter of fact, whatever work they are doing on the side in their laboratories, is all to their advantage if they discover a new method which is cheaper or faster?

General METZGER. It is very much to the advantage of the titanium industry, and most certain of great advantage to the Government in that a continuous process should not only increase the supply and provide expansibility, which we would need in the event of a mobilization effort, but also would reduce cost.

Senator MALONE. Well, where, if any place, is the Government conducting research for a continuous process?

General METZGER. Well, I believe that the United States Bureau of Mines is doing work along those lines.

Senator MALONE. Right here in Boulder City?

General METZGER. I don't know whether it is here or not.

Senator MALONE. We will find out about that later.

General METZGER. Yes, but I do know that many research companies and groups are working on other processes, continuous processes such as electrolytic processes, iodide processes, which would lend themselves to a continuous production line.

Senator MALONE. You seem to need this material so badly that you have, through the Department of National Defense, demanded that the Bureau of Mines go into production here.

Does that production, handicap or restrict the Bureau's laboratory work to discover a new continuous process?

PRAISES BUREAU WORK

General METZGER. I think not, definitely not. The work which the United States Bureau of Mines has done at Boulder City, I personally feel is responsible for the state of art of the production of titanium today.

The work has been of immeasurable value to the country and to the industry. I am sure that it has in no way handicapped them in their attention toward refinement of the process or development of new processes.

In fact, I believe that the work the small production at Boulder City of the United States Bureau of Mines was essential to the refinement and development of the Kroll process, or essential to the development of any other process.

Senator MALONE. Their production would help in the search for new methods, and better and cheaper ways of making titanium?

General METZGER. I think so very definitely.

Senator MALONE. Mr. Wartman has come to my attention many times in the last several years as the real father of a lot of the work at Boulder Dam. Very few people who do research work ever receive recognition for their work, but I intend to bring him to the attention of the Bureau of Mines for some kind of recognition.

General METZGER. I think Mr. Wartman certainly deserves it. He has made a great contribution, as have his people, and the people at the United States Bureau of Mines at Boulder City.

Mr. Matson and others have been in this without benefit of gain, personal gain whatsoever. They have contributed their time and energy and have performed great service to the country.

Senator MALONE. That happens many times.

I remember several years ago, maybe 15 years ago, the Bureau of Mines was working with the University of Nevada and perfected the method of producing electrolytic manganese. This method has received little attention but could become very important in the field under certain conditions, and is being used now.

I think there should be more attention paid to these men.

Will you proceed with your statement, General Metzger?

General METZGER. Senator Malone, would you care to pursue any further the development work of companies?

Senator MALONE. Yes; I would like to take up the DuPont Co. now. They seem to be the only other company now in production. Then, of course, mention the status of the Cramet Co.

The committee is interested, I might say at this time, in anything you can offer us that will add to our knowledge as to present and possible future demands, consumption, production, and the processes used in the production of titanium.

This is not a criticism of any company or individual, or even the Government, because the Government people are in between two fires.

If they let too large a contract for something that is not perfected and costs so much money, they are subject to criticism if it doesn't work out. On the other hand, if they let no contracts, or too small contracts, and due to war, production of large amounts of titanium becomes necessary for our national defense, they would be subject to criticism. We must get into production if we are to cheapen the process, so we are just at the point where a Senate committee might be of some help to the producers and to the individuals like yourself.

So if it seems that we are going into considerable detail, it is mostly for our engineers and technicians to interpret this for the committee so proper recommendations can be made.

I hope it will not be considered a criticism of any company or individual.

General METZGER. I am glad you made that remark, Senator Malone, because I have omitted making that remark personally. I am sure it is understood by all that any remarks I make, officially or unofficially, are not intended in any way to be critical, or are intended to be in the form of criticism.

Senator MALONE. What we need from you and your associates—and we will be calling you and your associates to testify further in Washington—is the exact status of titanium production, what in your judgment can be done to speed up production, what your present uses of titanium are, and what you would do with it if the designers were assured that they could get all the titanium they wanted.

General METZGER. I understand.

Senator MALONE. Your remark that the raw material is available in the United States, and in this hemisphere, for any amount of manufacture, once the processes are perfected to do it, is really the crux of the matter.

If we can be assured, and I think we can before we get through, that the entire 77 materials, minerals, and fuels can be made available in the United States of America under certain conditions, or at least speeded up, we want that assurance.

Perhaps there might be one or two materials that you could haul by airplane, such as industrial diamonds, but we are now dependent upon areas across both oceans for some materials which must be shipped by boat. We depend on Burma for tungsten, the Malay States for tin, Africa for manganese and chromite.

We are now getting manganese from India, but 24 hours, or maybe 2 hours after an all-out war was under way, the only way we could pay any attention to India would be on a map.

General METZGER. That is correct.

Senator MALONE. So having served as special consultant in an all-out war to the Senate committees and to the Secretary of War, I know by sitting with the War Production Board that the Germans with the old type submarines were sinking from 88 to 90 percent of our shipping coming out of Africa with chromite and manganese.

So most military strategists, believe that if we had to ship these materials across either ocean through the submarine menace and atom bomb, it would be a miracle if we secured enough production to keep our factories going.

So that is the reason the Senate has charged this committee with determining the availability of these materials in wartime. This is

the first time it has ever been done, but if we are going to talk war, we had better talk about what we are going to do if we have it.

Your remark that the necessary material is available in the Western Hemisphere is enlightening, and it is then up to us to do something about it. We have always whipped scientific and laboratory problems and we can do it now.

Do you agree this is a very important step?

General METZGER. I think this is a very important step. I am only sorry it wasn't done some time ago. It doesn't do any good to be sorry, but this interest at this level in problems of critical materials and the self-sufficiency of this country is essential to the security of this country.

Too little thought has been given to it. We live in a land of plenty, but the very fact that your committee has developed that there are 77 critical materials, critical to the production of weapons that we might need in defense of this country, or critical to the——

Senator MALONE. Economy.

General METZGER. Maintenance of a healthy economy or a minimum economy in the event of war, the very fact that has been developed, if brought to the attention of the public and if something is done about it, is a tremendous step forward in the security of this country.

MUST REDUCE COST

Senator MALONE. Well, debate in the Senate indicates the Senators want this information because they believe they can bring about a meeting of the minds and of course, furnish the required money from the producers; that is, the Titanium Corp., the Du Pont Corp., Cramet, and any other companies to which contracts may be let. We hope to close the gap between present price of $15 a pound, which is too expensive for commercial use, and the $2 or $3 a pound which have been mentioned to the committee. I was going to ask you a little later what you thought about these matters.

But the purpose of the committee is to assist the producers and the Department of National Defense and also, the commercial users for the very reason that once a thing becomes commercially available, the national defense doesn't have to worry as it can then be produced in this country.

General METZGER. That is correct. That is where we should find ourselves in the position that industry through commercial use provides the capability to support a defense effort. That is where we must be eventually.

Senator MALONE. There is no stockpile like a going concern industry.

General METZGER. That is correct; I think it is recognized that the greatest stockpile is the strength of this country, the industrial might of this country.

Senator MALONE. Thank you, General.

Now, if you will proceed with the Du Pont Co. along the same line of testimony you have covered with the Titanium Corp.

General METZGER. Well, as I mentioned before, Du Pont has a capability, when the facility is completed, to produce 10 tons a day or 3,600 tons a year.

In 1953 Du Pont produced 455 tons in the first 6 months.

Senator MALONE. January to June, inclusive?

General METZGER. Yes, sir; and it is forecast that July through December they will produce the same quantity.

Senator MALONE. 455 tons?

General METZGER. Yes, sir.

Senator MALONE. That would be how much, then, for the year?

General METZGER. For the year, 905 or 910 tons.

Senator MALONE. Instead of the 3,600?

General METZGER. They had a capability of 900 at that point. Their expansion is not as far along as Titanium Metals Corp.

Senator MALONE. Give us the program of expansion expected. In other words, what is expected this year?

General METZGER. That is all that was expected this year. Their rated plant capacity was fulfilled.

In 1954 it is expected that Du Pont will produce in the first 6 months 1,045 tons; in the second 6 months 1,655 tons, for a total 1954 production of 2,700 tons against a rated capacity of 3,600 tons.

It is expected in the first 6 months of 1955 they will reach their greatest capacity.

Senator MALONE. 1,800 tons?

General METZGER. 1,800 tons in a 6-month period.

Senator MALONE. Then they are complying with the terms of the contract?

General METZGER. Yes, sir.

Senator MALONE. Tell me about the quality. Does this production meet the specifications?

General METZGER. Well, these are shipped quantities, as we understand it from the information furnished us by GSA, and by Du Pont.

Senator MALONE. Accepted by the GSA, meeting the specifications laid down that you have heretofore placed in the record?

General METZGER. Yes, sir.

What they have produced off-quality or substandard in addition to this we don't know, but with a rated plant capacity of 900 tons which they should exceed by 5 or 10 tons, it is doubtful that they produced much bad sponge.

BUREAU PRODUCTION

Senator MALONE. Have you said anything about the actual production of titanium by the Bureau of Mines?

General METZGER. Titanium production?

Senator MALONE. Yes.

General METZGER. No, sir. The Bureau of Mines had a rated capacity of 216 tons annually, and our figures indicate they produced 32 tons from January to June 1953.

It is expected they will produce in the last half of 1953, 101 tons, for a total of 133 tons.

It is expected that in 1954 they will produce 108 tons in the first 6 months, which is their rated capacity.

Beyond that point I don't believe it has been decided that the United States Bureau of Mines will continue as a production facility. I think they will be in a position to discuss that point better than I.

Senator MALONE. It is believed that by that time the production elsewhere will take up the slack?

General METZGER. No, sir; it will not take up the slack but other considerations, such as for one, the Government in business may have a bearing on the continuation of the United States Bureau of Mines as a production unit.

Senator MALONE. If this metal is important, as your testimony shows, somebody better get into production fast.

General METZGER. It should have been in production, Senator Malone, prior to this. It takes 2 years to bring a facility into production. That is to the rated capacity, in any event, and with all the bugs and technical difficulties confronting any company in setting up a production unit, with the material and metal as new as this, it might exceed 2 years now with others to reach their rated capacities.

Senator MALONE. Being one of the men on the Senate floor who does not believe the Government should be in any kind of business where private business can do the job, I am also very adamant that we spend whatever money is necessary on pilot plants or even for actual Government production such as occurred in synthetic rubber, until private companies can take over and go ahead on a commercial basis.

Without synthetic rubber we could have lost World War II. Without enough titanium, if some other nation, a potential enemy, got into production we could lose World War IV, could we not?

General METZGER. Yes, sir.

Senator MALONE. Well, aren't we at the point where we better start looking at our hole card and do what is necessary?

General METZGER. I think it is essential that we do it, and do it immediately.

Continuing with this supply picture, at this point there are still 8,800 tons of a certified expansion program uncontracted, with a lead time, I think, of 2 years to bring it into production.

Senator MALONE. And within the 3,600-ton per year you discussed?

General METZGER. That was within the 22,000 tons.

Senator MALONE. Yes; I am sorry.

General METZGER. Still 8,800 tons uncontracted. It poses a problem, there is no question about it. It is a problem to industry and a problem to the Government as to whether this balance, or whether additional facilities, should be built around the present method.

It is as great a problem, or a greater problem, I would say, for industry than it is for the Government, because the method employed in underwriting this expansion requires a capital investment on the part of industry, and industry is understandably hesitant, I believe, to proceed with capital improvements of rather significant proportions around a process which may not be the final answer.

Senator MALONE. Are you familiar, General, with the work going on in the laboratories throughout the country, not only to perfect the Kroll method but to develop new methods?

General METZGER. Yes, sir.

Senator MALONE. And their status?

General METZGER. Yes, sir, generally.

PROCESSES

Senator MALONE. I hope you can give the committee some idea of the progress you believe is being made in the laboratories not only on the Kroll process but on other processes.

General METZGER. Well, there are two other ideas or processes which are under study by a number of companies.

One would be the electrolytic process, which is the same process used in aluminum and magnesium, a continuous process.

Considerable money has been spent, private capital has been spent, and some Government support but not very much has been given to the development of an electrolytic process.

There is a research organization in Cleveland, Ohio, which is a very able one in my opinion, known as Horizons Inc., who have worked on an electrolytic process with the support of the Bureau of Naval Research, and they have brought that process to a point where in laboratory methods it looks to some of us who are not properly qualified perhaps to evaluate it, as if it had a lot of promise, a lot of possibility.

The question now of proving the laboratory methods in a small pilot operation is before us, has been suggested to us by this company and we propose to give it as much study as we can, with the advice of the United States Bureau of Mines.

I propose to ask Mr. Wartman if he will not give us that process—not give that process a check, and with his advice, if it looks as if it has a good possibility, I propose to request Air Force funds to support and finance a pilot operation.

The DMPA route is a rather devious one and rather tortuous, and again I want to make it clear that I am not voicing any criticism. It is time consuming and time is against us; we can't wait.

While it is not within the area that we in the military service should operate, that of proving out or expanding basic industries, we shouldn't nor do our budgets ever include such projects and funds, yet due to the emergency—and we consider it an emergency—I will attempt to finance it if, in the opinion of the best minds we have along those lines, it has a chance of paying off.

Senator MALONE. You consider Mr. Wartman one of the outstanding men in the field?

General METZGER. I certainly do. Kaiser Steel has been working on a process, but what it is I don't know.

Senator MALONE. They are represented here and no doubt will offer some testimony later.

General METZGER. A year ago I spent some time with them in trying to guide the thing along and suggested that they immediately approach DMPA for whatever support, financial or otherwise, they felt would be necessary to proceed with a small pilot prove-out program.

They also, I believe, have gone through the laboratory stage.

Kennicott Copper had a process; Union Carbide is interested, too.

Senator MALONE. Are they doing laboratory work also?

General METZGER. Yes, Union Carbide is. Union Carbide has access to the development work of Horizons.

Senator MALONE. Let me ask you at this point, General, you remember during World War II there was interchange of information between laboratories of various companies whenever it seemed they were working on the same process, or where an interchange of information would save laboratory time.

Is there any interchange of information now with respect to the Kroll process and any other processes?

General METZGER. Unfortunately there has not been. The desirable free exchange of information between the producers, in my opinion, has not occurred. I believe many of the headaches which they have been having—and I refer to Titanium Metals Corp., if I may—could have been eliminated had a free exchange of information been undertaken or provided between the Bureau of Mines, Du Pont, and Titanium Metals Corp.

Whether they are getting together at this point or whether that information is available generally, I don't know; I doubt it.

Senator MALONE. The Bureau of Mines information would be available to either one, would it not?

General METZGER. If requested.

Senator MALONE. Let me ask you this. Naturally we have a patent law, and I have been a great supporter of the patent law. I have been in the engineering business for 35 years, and about the only reward for laboratory work—where thousands, hundreds of thousands, or even millions of dollars may be expended by companies or individuals before any results are obtained—is the use of the process they developed over the patent period.

Has there been any attempt to work out a common ground where companies like the Titanium Corp. or the DuPont Co. could really exchange information subject to protection for any production outside of national defense production?

Are their own patents protected after the interchange of information?

I think that would be a very important point to any company that is pouring hundreds of thousands of dollars into the laboratories.

General METZGER. I don't believe the patent problem or proprietary rights consideration has in any way entered into this free exchange. The Kroll method basically is a method in use, and that is on a royalty basis.

Senator MALONE. Isn't it a fact that a basic process patented by a company or an individual that pours the money into it, eventually is of very little value unless you have subsequent patented improvements of the basic patent?

You know the Kroll process is being used by both, but if one of them patents an improvement on the Kroll process, naturally in commercial work they would want to profit by it to get back some of the money expended in developing the improvement.

What I mean by that, if there was a free interchange of information, how could the patent holders be protected with respect to any production exclusive of Government requirements?

SHOULD INTERCHANGE IDEAS

General METZGER. I have been asked by certain of the industry concerning that same question. I think what we are talking about is equipment design and plant layouts, refinements to the Kroll process and its local company know-how, which has been gained through some considerable expense.

I don't believe it is patentable, and that may be the problem. It is just a question of exchange of know-how. How you overcome this, and so forth, and so on, in equipment design, and so on.

I believe that has a very large bearing on some of the difficulties that have confronted some of these companies.

From information I have received, and it is of a generalized nature, I think that Cramet should have had available prior to the ordering of equipment and the design of equipment for their plant, should have had available the know-how and the technicians of the Bureau of Mines and the Titanium Metals Corp. and du Pont.

Senator MALONE. Well, without question they will have the Bureau of Mines know-how.

General METZGER. They will have; again, if they don't have it, it is their own fault.

Senator MALONE. But you think it should go further and there should be an interchange of ideas by du Pont, Titanium, and Cramet, and any other company which might get into production for national defense purposes?

General METZGER. Yes, sir. I have always taken this position, and I made it very clear when confronted with the problem, such as you are posing here, and when we try to do something in the way of supporting a program that was good for the titanium industry in its infancy, that is good for everybody in the country, and I see no reason to withhold information on any part of it.

Senator MALONE. It may be that your position might gain weight due to the fact that none of the producers may be able to do what they are doing now except for Government money——

General METZGER. That is true. I don't believe any of them would have gone forward without that Government underwriting.

Senator MALONE. Yes, with this Government help. I am convinced, and I think our committee will be convinced before we get through, that in any strategic or critical materials in which our production is deficient or nonexistent, Government money should be used to bring about or increase the production of these strategic and critical materials.

That is, when Government money is going into these various projects there might be added weight to your argument that they should cooperate. There is no question but what synthetic rubber probably would not have been available for 25 or 50 years if it hadn't been for the use of Government money in its development. That also applies to a good many of these materials, such as zirconium, does it not?

General METZGER. It certainly does.

Senator MALONE. What about the mill products? After you produce sponge, where is it milled and made available for your use?

General METZGER. There are 3 or 4 principal converters and producers of mill products.

There is Allegheny-Ludlum Steel, which utilizes substantially the entire output of Titanium Metals Corp., in producing stock, bar stock.

Republic Steel is a substantial producer, and they get their sponge from Du Pont, I believe. Remcru is another.

Senator MALONE. How do you spell that?

General METZGER. R-e-m-c-r-u.

Senator MALONE. Where are they, in Pittsburgh?

General METZGER. Midland, Pa.

Malloy-Sharon Steel also operate, I believe, with Du Pont sponge.

The Japanese sponge which we talked about earlier will undoubtedly be, if it is imported in substantial quantities, used by one of those companies or more.

Senator MALONE. It is being imported at this time?

General METZGER. Yes, in small quantities.

Senator MALONE. Do you know the quantity?

General METZGER. 10 tons a month is their production, but I don't know what is being shipped here.

Senator MALONE. You don't know what their plan of expansion is?

General METZGER. They are expanding, yes, sir, but we don't have the details on it. They are very much interested in expansion.

Senator MALONE. How does the quality compare to the quality of our production?

General METZGER. We hear it is very acceptable; it is comparable.

Senator MALONE. They are very energetic people.

General METZGER. Yes, they are.

Senator MALONE. And their wages are very low.

General METZGER. Wages are low and they have plenty of manpower.

Senator MALONE. The time might come when they would be competitors of ours in the production of titanium, would they not?

General METZGER. They could be; yes, sir.

Senator MALONE. That is all of the mill producers?

General METZGER. Well, there are others, but these are the principal producers as we know them.

Senator MALONE. Tell us something about the cost of the sponge, and the cost of the sheet as it becomes available for your use from the various sources.

General METZGER. Well, when we speak about costs, Senator Malone, I will refer to selling price.

Senator MALONE. Yes, of course, what it costs us.

General METZGER. What it costs our manufacturers.

Senator MALONE. That is right.

General METZGER. It is our understanding that the market price for sponge is $5 a pound.

Senator MALONE. And is that what you pay for it under contract with these companies like Titanium Corp. and du Pont?

General METZGER. We buy no sponge. In fact, we buy no mill products; our manufacturers do.

Senator MALONE. I understand; I was a little ahead of the game there, but what is the price you take into consideration in your contracts with the manufacturers?

General METZGER. Well, we pretty generally figure that our manufacturers who are to put titanium in our equipment, in mill product form without manufacturing loss, this gross will approximate $20 a pound.

Senator MALONE. In a rolled sheet?

General METZGER. It depends on the shape and form and the product.

Senator MALONE. And $5 a pound for the sponge?

General METZGER. Yes.

Senator MALONE. In other words, to roll it and prepare it in the shape form costs about $15 per pound?

General METZGER. Plus the losses which accrue; yes, sir.

RECLAIMING SCRAP

Senator MALONE. Would you give us a description of these losses? It is the understanding of the committee that at the present time the scrap is not reclaimable like scrap steel.

General METZGER. That has been the case; that is correct, Senator Malone. It obviously becomes the quickest way to increase supply to reclaim the scrap. Substantial scrap is generated, not only in turnings and borings and croppings of mill products but also in the scalping of ingots and in bad sponge itself, or off-quality sponge, I should say.

Senator MALONE. About what percentage of the sponge purchased for $5 a pound turns up in the finished material?

General METZGER. About 60 percent.

Senator MALONE. 40 percent waste?

General METZGER. Yes.

Senator MALONE. Is there any practical method of reclaiming the scrap at this time?

General METZGER. We think so. We came about it more or less by accident.

If I may just digress here a moment, although I think it is pertinent to the committee's interest——

Senator MALONE. The committee is interested in ascertaining whether the price of the finished material could be lowered. If there is a practical method for reclaiming scrap, we think the chance of obtaining a lower price would be much greater.

General METZGER. Recognizing that scrap was accumulating in the country at a rather terrific rate even with low production of the metal, and reaching something in excess of a million pounds of scrap in various forms, we undertook in the Air Force——

Senator MALONE. You say that amount of scrap has accumulated?

General METZGER. Yes, sir.

Senator MALONE. And is available at the plants?

General METZGER. Scattered throughout the country, not too much of it reaching the junk dealer because there is nothing much he can do with it.

Senator MALONE. But they are saving the scrap, hoping a method will be developed in order that the scrap can be reclaimed?

General METZGER. Yes, sir.

We undertook to manufacture a scrap process development and we sent proposals out. We had a million dollars that I was willing to spend to get a good scrap process development program under way.

We learned right about that time that industry, of its own accord and at its own expense, had been of course proceeding along those lines and that one process had been developed by Allegheny Ludlum Steel which showed great promise.

We have taken a look at it and DMPA is presently reviewing it. It will require some financial support, but I believe that if DMPA feels that the process has good possibilities that they may support

Allegheny Ludlum in providing the facilities to engage in this program.

But I think also that that process, that development or technique—whatever you wish to call it—is a good one and should be made available to anyone who wants to get into the business.

Senator MALONE. Again, you think that as long as Government funds make this possible, an argument can be made for the interchange of ideas and laboratory results?

General METZGER. Yes, sir. So I have great hope that the scrap problem will be solved within the near future.

Senator MALONE. Is the Bureau of Mines working on that also?

General METZGER. I don't know, Senator Malone, whether they are or not.

Senator MALONE. If a practical method of reclaiming this scrap turns up, what would happen to the price? What immediate effect would that have on the price of the finished product?

General METZGER. I don't believe it would have any. It might stabilize or increase the price of the scrap, which would reduce the final cost of the application of our product.

Obviously at this point, or up until now, being itself of little value, and since our manufacturers secure little, if anything, for it, if something can be done with it and it is not an expensive process—that is, if metal can be produced from this scrap in this program, why, it will increase the cost or the selling price of the scrap.

Senator MALONE. And that, of course, will reduce the net cost?

General METZGER. Yes.

Senator MALONE. To that extent, anyway?

General METZGER. Yes.

Senator MALONE. One more question before our noon recess.

Is it a fact that the production program for jet engines and other material is, and has been delayed on account of the lack of titanium and assurance that sufficient quantities of the metal can be obtained?

General METZGER. We have had no schedule slippages to this point due to our manufacturers' inability to secure the metal, but it has been touch and go and much metal has been used which was not up to standard in quality, requiring additional expense in working it. Much more scrap and rejections have been encountered which increases cost, but we haven't missed a schedule.

That is because the application or use of titanium to this point is small in relation to what it will become 6 months from now.

Senator MALONE. What you mean is that you have held down the use of titanium in your specifications to an amount you were assured would be produced. What you really mean is that you could have used much more titanium if you were assured that more titanium would have been delivered?

General METZGER. That is right, sir, and we have allocated, as I mentioned earlier, directed shipment to those aircrafts and equipments which offered us the greatest military advantage.

So if we had not exercised some control, such as an allocation control, we could have slipped schedules without question.

Senator MALONE. Immediately after the recess I intend to ask you what kind of a production schedule would have to be maintained in order to eliminate the allocation of titanium.

It is now 10 minutes after 12. We will recess until 2 o'clock.

First I want to list the appearances, but we will do that off the record.

(Discussion off the record.)

Senator MALONE. We will recess at this time until 2 o'clock.

(Whereupon, at 12:30 p. m., a recess was taken until 2 p. m.)

AFTER RECESS

(Whereupon the hearing was resumed, after the taking of the recess, at 2 p. m.)

Senator MALONE. The committee will be in order.

FURTHER TESTIMONY OF GENERAL METZGER

Senator MALONE. General, I believe when we called the recess at noon that we had discussed the actual producers and had reached the Cramet Co., to which a rather sizable contract had just been let.

Will you begin with that company, and if you have more details on the other companies, just supply this information, as you go along.

General METZGER. All right, sir.

Cramet is under contract to produce 6,000 tons of sponge annually.

It is forecast that they will come into production in the first half of 1955, with an estimated production of 800 tons.

In the last half of 1955 it is estimated that they will produce 2,100 tons, for a total production of 2,900 tons for the year 1955.

They will follow that curve, hitting their peak of 3,000 tons semi-annually, or 6,000 tons annually in the first period, the first 6 months of 1956.

I am sure that it is recognized that this is an estimate, and I feel that if everything is favorable, they will make it.

However, based upon the pattern of other producers there can well be disappointments.

Senator MALONE. Your opinion that Cramet would reach full production on schedule is based on the past experience of actual producers, the added experience of the Bureau of Mines, and information Cramet can obtain from other sources?

General METZGER. Well, if they do avail themselves of all the information which is available in the way of background and experience to the other producers it will help materially in eliminating errors that could creep into their production technique.

I am assuming that they will be able to construct their plant on schedule, secure their equipment on schedule and that the power will be available.

I understand that they have chosen a site at Chattanooga, Tenn., for this plant, and they are about to begin clearing the site, if they have not already started.

Senator MALONE. Do they have the necessary power there?

General METZGER. That we don't know. We have heard that TVA power is pretty well committed, but have had no opportunity to verify either the power commitment to Cramet or the fact that it is pretty well committed.

Senator MALONE. Tell me at this point, this is the Kroll process; is it not?

General METZGER. This is a modified Kroll process.

Senator MALONE. What do you mean "modified"?

General METZGER. Well, I think, Senator Malone, you very ably expressed it this morning, the fact that a basic process is changed, and through various refinements and modifications, and I assume that Cramet, who have been engaged in a pilot operation for well over a year, have made some refinements of their own.

Senator MALONE. Basically, it is the Kroll process?

General METZGER. Yes.

Senator MALONE. What is the power requirement in kilowatt-hours per pound for a contract such as this?

General METZGER. It is our opinion that from the information we have been able to gather from the Bureau of Mines, and from other producers, that the power consumption per pound of titanium sponge on the end of the Kroll process approaches 11 kilowatt-hours.

That is an assumption that there is no regeneration of magnesium and chlorine.

If there is an operation of regeneration of magnesium and chlorine conducted at the site, it will approximate 16 kilowatt-hours per pound of titanium sponge.

Senator MALONE. Sixteen kilowatt-hours?

General METZGER. Yes, sir.

Senator MALONE. Is the regeneration of magnesium or chlorine a customary or unusual procedure?

General METZGER. No; it is not unusual. It is in effect here at Henderson at the Titanium Metals Corp., and also at Du Pont. The Bureau of Mines are selling their magnesium chloride.

Senator MALONE. Then, 16 kilowatt-hours per pound of sponge could be counted upon as the possible power requirement?

General METZGER. Under the Kroll process, and I think that is what we are talking pretty specifically of at this point concerning Cramet. There is a possible reduced requirement under an electric process.

Senator MALONE. We were informed from another source that the general requirements under the Kroll process was about 20 kilowatt-hours per pound of titanium sponge.

I wonder what would cause that difference in power requirements?

General METZGER. Well, there has been considerable speculation as to the actual power consumption and power requirement, and I have also heard that figure of 20 kilowatt-hours per pound used.

This is the information that I am giving the committee here, information which we have developed and secured from, as I mentioned before, present producers. I think perhaps the producers themselves could go into that.

Senator MALONE. Yes, we will go into that.

Also we have been furnished a figure of approximately 26½ kilowatt-hours per pound for the finished ingot?

General METZGER. That is correct.

Senator MALONE. That is the correct figure for the finished ingot?

General METZGER. Using the same basic approach here on the sponge production. That would be the total.

Senator MALONE. This was assuming that it took 20 kilowatt-hours per pound of sponge under the regular process.

General METZGER. Yes.

Senator MALONE. Well, a 6,000-ton annual production would be about 15 tons a day?

General METZGER. Yes, about 15 tons; 360 days you figure.

Senator MALONE. Well, that requires quite a sizable amount of power.

General METZGER. Yes, sir; I haven't bothered to multiply it here. We can do that right now and put it in the record.

Is that to sponge or to ingot?

Senator MALONE. I would like to know something about kilowatt-hours needed to produced sponge and ingot.

General METZGER. About 192,000,000 kilowatt-hours annually to produce 6,000 tons is the way I figure it very quickly here.

That is figuring 16——

Senator MALONE. Tons of sponge?

General METZGER. 6,000 tons of sponge, yes.

Senator MALONE. With respect to power requirement for your full production, which is to be 35,000 tons annually——

General METZGER. 35,000, I think.

ANNUAL PRODUCTION

Senator MALONE. Would you recapitulate here briefly, General, and show how many tons we are producing annually now from the three private producers and the Bureau of Mines, how many tons each is producing and what they will be producing when they reach the present contract limit, and what additional contracts are necessary to bring the annual production to the 35,000-ton figure?

General METZGER. Well, it is estimated that the 1953 production of sponge will be 3,047 tons.

Senator MALONE. That is the total from the three private sources?

General METZGER. From the three sources.

In 1954, 6,408 tons.

In 1955, 13,400 tons.

We reach a limit under the contracted quantity of the 13,000 tons per year.

Senator MALONE. That is all that is contracted for now?

General METZGER. Yes, sir; so that 400-ton figure which I used, we rounded off to 13,000 really.

Senator MALONE. What is the nature of the program by which we hope to attain the 35,000 tons per year?

General METZGER. Well, as I mentioned earlier, the DMPA certified expansion program——

Senator MALONE. This DMPA, is still in existence is it not?

General METZGER. It is still in existence, although we hear that there has been considerable reorganization and change of faces. I know that to be a fact, that there are certain people who have been in this program and in the DMPA who are no longer there. I don't know what the plans are for that agency.

Senator MALONE. But the DMPA will be the central figure in the letting of further contracts to raise production to 35,000 tons per year?

TIME ELEMENT

General METZGER. Well, 35,000, if they go to 35,000. So far they have only approved 22,000, although the Department of Defense requested a capacity of 35,000 based upon requirements, firm and projected, which were furnished by the military departments.

So if we just talk at the present of 22,000 tons certified, that is still 8,800 tons uncontracted balance.

As we mentioned earlier, that is serious, due to the time necessary or required to bring a production facility into being.

All the time we find ourselves, and the military aircraft program find themselves, in an increasingly deficit position, deficit with respect to requirements and the availability which I mentioned a moment ago.

Senator MALONE. If you had under contract, and had a reasonable expectancy of receiving 35,000 tons within 1 or 2 years, would that allow your designers and the Defense Department to include increased use of titanium in your specifications?

General METZGER. Well, the magnitude of our program is such that it would have a direct bearing upon that, and the appropriations which we may receive will well control what we may buy in terms of numbers of aircraft.

Senator MALONE. But your appropriations would have nothing to do with this production?

General METZGER. No, sir.

Senator MALONE. And there would be no reason to get the appropriations unless you had the material?

General METZGER. Well, we will be forced to buy, perhaps, aircraft and equipment of an inferior quality in order to build the strength within the aircraft program, within the Air Force and the Navy program, which has been dictated as essential by the Joint Chiefs of Staff.

Senator MALONE. Right at that point it seems to me this is the crux of the whole business. If another nation, a potential enemy, had titanium we would be building an inferior air force.

General METZGER. We certainly would be building weapons and equipment less desirable and less potent than we would be building if we had the materials we needed.

Senator MALONE. And these planes would be obsolete just as soon as titanium became available to you and you were able to start constructing new types using titanium?

General METZGER. Well, I don't know, Senator, whether "obsolete" is the word or not.

They certainly wouldn't be as useful as aircraft which was produced with superior characteristics.

Senator MALONE. Well, as a matter of fact, the second best airplane is a good deal like the second best poker hand.

General METZGER. That is just about right, sir. They may be relegated to different missions of a less important consideration; some may revert to trainers.

Senator MALONE. You have a possible use for them, but you wouldn't be able to produce such planes when you need them the most.

General METZGER. No, sir.

Senator MALONE. General, the 35,000 tons has been fixed as a target, but as a matter of fact, if you could wave a magic wand and obtain all the titanium you desire, what would your sights be then?

General METZGER. Well, again, Senator, we would employ or we would use that titanium which was necessary to build the best equipment and best aircraft that we could possibly build. If we were authorized to buy any particular given number, or given funds which would support any particular number of wings, why, purely as a matter of mathematics to develop our requirements—well, what I am trying to bring out here is that it becomes difficult for us to forecast the impact of our program upon industry, the materials industry, the fabricating industry, or any other segment of industry until we know the size of our program.

This program is dictated by congressional appropriations which, in turn, are, as you know, influenced entirely by the needs of the country in terms of security, and the international situation.

Senator MALONE. General, I recall in 1947 or 1948 or 1949, the President sent up a request for 56 air groups. No one on the Senate floor was ever too specific as to just what constituted an air group, but at least we assumed the Department of National Defense understood it.

I was one of a group of 4 or 5 Senators who are very sensitive to air power, since improper balance of air power might cause our defeat in a war, so we took the program away from the President and appropriated money for 70 air groups, and he built 46.

There and then, according to the history of the debate, we lost control of the air. We would have ordered a hundred or 150 air groups if men like yourself had come and said, "We have the material; we are ready to build them and we need them."

You have traveled 3,000 miles to be with us here, and it is very much appreciated because you are sitting right at the seat of the construction of one of the largest plants in the titanium industry.

There isn't any use of you and me wasting time about what Congress is going to do. The only way Congress is going to know what to do is to receive information from men such as you who are experts in their fields and know what they are talking about, just as I do when I talk about an engineering problem in my field.

I am now asking for information for the committee. Forget about what Congress may or may not do. I think it will do whatever is necessary. But Congressmen are very nervous now, and I think the whole country is nervous about producing a lot of materials and equipment that are obsolete as soon as they are produced, and which will go to Europe, be stored, and probably never used.

There has been testimony before the Senate Finance Committee—of which I am one of the newest members—that a very large amount of our money is going to pay for materiel contracted for 2, 3, and even 4 years ago.

Now, it is under construction and being finished and the bills are being paid.

The question was asked in the committee, how much of it is obsolete when it hits the ground, and no one seemed to know. I believe the Senate, and although I am not speaking for the House, but I am

sure it and the country is waiting for some authoritative information as to what these up-to-date, newest planes, submarines and fighting equipment should consist of and how much is needed.

I don't know whether you need 1 or 500 big bombers that may be able to travel at the speed of sound. You probably know. I expect it is classified information, but it is not classified when you go up before the Appropriations Committees to get money. As far as this committee is concerned the information would be available to all in private or executive session.

General METZGER. That is right.

DEMANDS TO INCREASE

Senator MALONE. So what would you ask for today if you ran the whole show and had confidence Congress would go along with you? Would you say you need 100,000 or 250,000 tons a year?

They tell me tanks will be made out of this material?

General METZGER. That is correct.

Senator MALONE. A tank can be made much lighter and stronger.

General METZGER. That is correct, Senator.

Senator MALONE. And engines; all transportation and fighting equipment.

So if today you were in charge of the program and you could gather these men around you, and you believed you could hit the peak you wanted in the next 5 years, what production would have to be assured in order for you to get the plans off the drafting board and get started?

General METZGER. Well, Senator, I would like to answer it. I will be very glad to answer that question.

First. I would like to state frankly that the military aircraft requirements for 1953 will be approximately 3,500 tons of sponge to support our military product requirements.

In 1954, approximately 9,800 tons.

In 1955, approximately 19,000 tons.

For 1956, it becomes more difficult to plan and the estimate may not be as good, but I would say 35,000 tons.

Senator MALONE. That is the amount now that you have projected?

General METZGER. No, there are only 22,000 projected.

Senator MALONE. The Department of Defense has asked for that amount?

General METZGER. Has asked for that.

Senator MALONE. And this is only for planes?

General METZGER. The Department of Defense request was in support of the Army, Navy, and Air Force requirements.

Senator MALONE. In addition to planes?

General METZGER. In addition to planes.

The Army and Navy have been very forthright in their approach to this titanium situation, and have publicly stated that due to the limited supply it was felt that it was to the best advantage of the country to withhold their planning and path in favor of the military aircraft program, and that is about what has been happening.

So I really don't know what requirements have been generated.

Senator MALONE. If they could substitute titanium in other materiel besides planes?

General METZGER. That is right; it would be generated in the other two departments.

Senator MALONE. Could it easily double?

General METZGER. Easily.

Senator MALONE. Maybe triple?

General METZGER. Yes.

Senator MALONE. Which would be around 100,000 or 105,000 tons?

General METZGER. Yes.

Senator MALONE. As of today, you have yet to let contracts for 21,600 tons of annual production?

General METZGER. There are only 13,800 tons actually contracted.

Senator MALONE. Well, approximately 13,000?

General METZGER. Yes, approximately 13,000 tons contracted for.

Senator MALONE. What you have is approximately 22,000 tons of annual production, which you actually need for military plane production up to and including 1956, and for which no contracts have been let?

General METZGER. Yes, sir.

Senator MALONE. And that requirement is what you have on the drafting board and you are actually working on it.

General METZGER. Yes.

Senator MALONE. Which no doubt could be speeded up if you were assured the titanium would be available?

General METZGER. Well, unquestionably if the material were plentiful the demand would greatly exceed figures I have given.

Senator MALONE. The 35,000 tons?

General METZGER. I think so.

Senator MALONE. Even for your planes?

I have no desire to have any information in the record of a classified nature in the record, but your plans depend a great deal on the overall plans for the defense of this Nation, is that correct?

Whether we are going to stress air protection for this hemisphere, or whether we are going to place foot-soldier armies all over the world, is a policy matter currently in a state of flux?

General METZGER. That is true. I believe the President has requested the Joint Chiefs of Staff to present another set of requirements for defense, for such requirements to include those of all three departments, and the Joint Chiefs, I believe, are working on that now. Whether it will be presented, I don't know.

Senator MALONE. Well, I hope so. The decision should be left to the Joint Chiefs of Staff to determine what materiel they need, and the type of defense they need. For 21 years our trouble has been that the Joint Chiefs have been given the plan and told to conform with it. I hope we do not now have the kind of generals who will support plans, previously determined by persons other than themselves. I do not think we do.

General METZGER. Senator, I would like to mention that we notice that there is a slip in the ordering boards of the producers due to a setback in our own use.

Our own manufacturers, due to their inability to secure the material, are postponing the date at which they incorporate the material in some

design changes presently approved, and I bring that out because some of the producers are here and I think it well that they realize, or hear from us, what we feel is the reason for a shift in the order load.

It is just the very fact that our manufacturers feel essential in planning their production to meet the schedule that they defer the use of titanium in presently designed and approved component parts.

Senator MALONE. Well, that leads to the question I was trying to frame earlier.

If you knew that in 1, 2, or 3 years from now you could get the amount of titanium you need, then your designers could now plan to use titanium. Then could you use 35,000 tons or would it be 100,000 tons?

That was the question I really meant to ask a while ago.

If your designers could plan to use titanium wherever feasible and necessary in the plans and specifications submitted to producers, couldn't this requirement of 35,000 tons easily double?

General METZGER. Well, Senator, again it would depend entirely upon the number of aircraft we bought.

Senator MALONE. Talking about buying the number of planes you need, Congress cannot make these plans.

I am a member of the Senate; I am not an expert in what you need, so all you can do is tell me and other Senators what you need. I am convinced the Senate and the House is going to give you what you need, but they are a little perturbed about where you are spending all this money.

You are spending 20 billion in Europe this year, 6½ billion in cash, 12 billion for a land army over there. Most people agree that Army will be in danger of suffering another Dunkirk in 48 hours if a war starts.

The remainder of the 20 billion is distributed at random in offshore purchases and repairs. Suppose you had that 20 billion dollars and somebody said you can put it in Europe or you can buy all the planes you need, and you had all the titanium you wanted, what would you do then?

Somebody has to be asked that question and somebody has to answer it, and Congress cannot answer it.

General METZGER. Well, these figures that I have been using here are requirements generated by a 143-wing Air Force, the attainment of a 143-wing Air Force, which is not yet attained, plus a sustaining rate to keep that Air Force modern at 143-wing strength, on a minimum basis.

Senator MALONE. For the record, would you describe the number and types of planes which a wing?

General METZGER. Well, again as you very aptly, Senator, mentioned awhile ago, that you had never been able to understand the number of aircraft in a wing——

Senator MALONE. I understand there are different makeups.

General METZGER. There are different makeups, depending upon the employment.

Colonel MACDONALD. A heavy bomber would be 30 aircraft for a wing; fighter aircraft, 75; in between there would fall the other groups with different roles and missions.

Senator MALONE. 75 planes in a fighter group?

Colonel MACDONALD. Yes, sir.

Senator MALONE. What in the way of bombers?

Colonel MACDONALD. A heavy-bomber wing would be 30 aircraft. Our largest aircraft, because of the difficulty of maintaining them, and the space requirements are held down to 36 aircraft per wing.

Senator MALONE. How many aircraft are there in a typical wing.

Colonel MACDONALD. It would be 30, for instance.

Senator MALONE. What?

Colonel MACDONALD. 30 of them would make a heavy bomber wing.

Senator MALONE. 30; and how many fighters?

Colonel MACDONALD. No fighters with that wing. There would be a fighter wing.

General METZGER. We are getting into some sensitive information, Senator; I am sorry.

Colonel MACDONALD. I think that is all right, the numbers of aircraft.

General METZGER. Well, the deployment information——

Senator MALONE. Off the record.

(Discussion off the record.)

Senator MALONE. On the record.

General, in my humble opinion and I can only speak for one Senator out of the 96, as far as Congress is concerned, 143 groups, or 56 groups—whatever the President asked for in 1946, or 1947, are only numbers to anyone who doesn't understand the makeup of a group and the reasons for it and how they are deployed.

In my humble opinion, if you joined together and said, we need 243 groups, made out of titanium you would get it.

If you made up your mind to use aircraft and submarines instead of foot soldiers all over the world and thereby saved about $20 million and spent it on airpower where a lot of us think it is needed, I think it would be better.

Of course, this is something that you can't say, I understand that, until you have considered everything and until they have made up their minds.

Some of us are in hopes that they don't think they have to follow what has been done for the last 20 years or 15 years or 10 years. They will get their feet on the ground and determine what is needed to defend this Nation.

So what I am trying to get at is that—and perhaps we will have to continue this in Washington in another kind of session—if you had the titanium or would have it by the time your plans came off the board and the companies were bidding on the construction and if they knew they could get it—then how much titanium would you need?

You have been fooling around here with 5,000 tons and 6,000 tons and 35,000 tons, because every one of you know you can't get it any faster than that right now, unless something revolutionary is done. There are a good many people ready to enter in and help you do this revolutionary thing if it is necessary.

General METZGER. That is very encouraging, Senator.

Senator MALONE. Well, you wouldn't want to estimate what would happen to the demand for titanium if you were turned loose to design the planes the way you want them and the numbers that would be necessary?

General METZGER. No, I wouldn't be in a position to estimate that. I would like to be conservative and rather realistic here, and confine my estimates to attainment of the 143-wing Air Force, and a certain quantity to sustain that 143-wing strength and keep it modern, and that, Senator is what I have used as a baseline here in these figures.

Senator MALONE. 35,000 tons?

General METZGER. Yes, sir.

Senator MALONE. That doesn't include any titanium needed for other purposes?

General METZGER. No, sir.

Senator MALONE. Which could easily amount to 35,000 tons or more?

General METZGER. I would say so.

IMMEDIATE EXPANSION DESIRED

Senator MALONE. I will ask you this final question: Do you believe it is necessary to immediately, if possible, but as fast as possible, expand the titanium production industry as it now exists?

General METZGER. I certainly do; I certainly do.

Senator MALONE. Would you consider it one of the most important matters facing the Department of National Defense and the Congress at the present time?

General METZGER. It is most certainly one of the very important, one of the very important matters which should be resolved and decided.

At this point, and I would like to repeat, we will be unable to proceed with the plans we presently have unless an expansion is immediately undertaken, and even then if it were to be undertaken today, with an uncontracted balance to be contracted, our plans will be deferred because it cannot be brought into production in time, in our opinion, in time to satisfy our requirements as we know them today.

Senator MALONE. Do you happen to know what are some of the bottlenecks in present production of titanium.

Is power a bottleneck in the production of titanium, General?

General METZGER. Power is essentially one of the first considerations which must be given, in our opinion. If the power estimates, power consumption estimates which we discussed earlier here—well, evidently that power in those quantities doesn't exist in too many places, if in any.

I think we all recognize that it is certainly uneconomic to try to take power in those quantities over long distances.

It is possible that power may be generated on sites through coal and gas, but hydroelectric power certainly cannot be transmitted economically over long distances.

I think the rule of thumb is that it doubles in cost every 400 transmission miles, or something like that.

Senator MALONE. Every 400 transmission miles, you say, General?

General METZGER. Yes, sir, it doubles in cost every 400 miles.

Senator MALONE. I think that is a conservatice estimate.

General METZGER. So power is very important, but with the quantity which we are presently talking about to be produced under the Kroll method, yet probably could be supported with power in being some place.

Senator MALONE. You spoke of an electrolytic process. Is there any indication that the per pound requirement of power would be less or more?

General METZGER. Well, it is estimated that it would be less. We have been using an estimate, and its validity I certainly can't vouch for because it has never been tried, of 5 kilowatt-hours per pound as contrasted with 11 for the Kroll process.

Senator MALONE. And the sponge?

General METZGER. Yes, sir. I imagine the conversion to ingot would be about the same power requirement under either process.

Senator MALONE. You described the du Pont contract and its status. Has that company applied for any additional contracts, or is it interested in making any additional contracts?

General METZGER. I am sorry, Du Pont cannot answer directly, but they are not present. I believe that they have about as much as they feel they can at this time. I could be wrong.

Senator MALONE. What are their plans for the future? Do they want to get into titanium business further?

General METZGER. If they have any plans, we are unaware of them, Senator Malone.

Senator MALONE. They have no application for further contracts?

General METZGER. Not that I know of. I believe that their 3,600 tons is all that has been requested.

I am sure you realize that those applications are never made to the Air Force. They are made directly to the Government, and there may be negotiations under way that we know nothing about. It would only be hearsay, and we would have no reason to know other than our constant drive.

Senator MALONE. To increase the production?

General METZGER. To increase supply.

Senator MALONE. How about the Titanium Corp.?

General METZGER. Titanium Metals Corp. has a request in for an expansion which has been deferred, as we understand it, to 5,400 tons.

Senator MALONE. Additional?

General METZGER. Yes, sir; I believe that is to be——

Senator MALONE. Annually?

General METZGER. Yes, sir. I believe to be produced here at Henderson, an expansion to this plant.

Senator MALONE. This is the only area in which the Titanium Corp. is producing, isn't it?

General METZGER. Yes, sir.

Senator MALONE. Why has this application been deferred?

General METZGER. I really don't know exactly, other than perhaps due to the difficulty that Titanium Metals Corp. has experienced in producing to the rated capacity of the present facility.

Senator MALONE. This 5,400 tons would be 15 additional tons a day?

General METZGER. Yes, just short of 15 tons a day.

Senator MALONE. And they have a contract now for 10?

General METZGER. Yes, sir, 10 tons per day.

Senator MALONE. If this production were to reach its peak, do you think at that point the cost per unit or per pound might be reduced, or when does the volume of production result in a substantial reduction in cost? Has there been any estimate made on that?

General METZGER. No; but looking at it very realistically, I have never seen a price reduction in any product that was in short supply.

Senator MALONE. I know several reasons for that. Sometimes they take what the traffic will bear, but the Government is familiar with the cost, and is also advancing $13 million to the Titanium Corp., isn't it? Do you know how much was advanced to the Titanium Corp.?

General METZGER. Around $13 million, if I remember correctly, to be repaid in sponge. That is, not to exceed $15 million with 4 percent interest. I believe some $13 million has been drawn against that, but I am not sure.

Senator MALONE. To be repaid in sponge at $5 a pound?

General METZGER. Yes, sir; we have all these copies of these contracts which I will be glad to submit for the record.

Senator MALONE. That will be the thing to do.

General METZGER. They are rather technical and lengthy and would require quite careful study to be sure.

Senator MALONE. That will include the Titanium Corp. contract, the Du Pont contract, the Cramet contract and the contract with the Bureau of Mines, or does the Bureau have a contract?

General METZGER. The Bureau of Mines operates under an appropriation, I believe.

Senator MALONE. Then there will be four contracts?

General METZGER. Yes, sir.

Senator MALONE. We will make them a part of your testimony, General.

(The contracts referred to are as follows:)

SUMMARY OF TITANIUM CONTRACTS IN FORCE

Prepared by DMPA

SUMMARY—GOVERNMENT'S CONTRACTS WITH PRESENT PRODUCERS OF TITANIUM SPONGE

Titanium Metals Corp. of America: Letter of Intent, July 24, 1952

(1) Quantity: 3,500 short tons per year extending for 5 years.

(2) Government's advance: Not to exceed $15 million with 4 percent interest for expansion of facilities.

(3) Advance repaid: On poundage payments at $0.47 for each pound of sponge produced to continue for 10 years after completion of facilities or until advances paid.

(4) Price: The lower of $5 per pound of sponge or average monthly market price of titanium sponge for month in which delivery is made.

(5) Specifications of sponge:

	Percent
Titanium (minimum)	99.3
Iron (maximum)	.25
Nitrogen (maximum)	.03
Total other impurities (maximum)	.70

Hardness, 250 Vickers of 224 Brinel.

(6) Sampling and analysis: United States Bureau of Mines methods and procedure.

(7) Obsolescence: Obsolescence of process or equipment if acceptable to Government the latter will advance supplemental funds for replacements.

(8) Operating at a loss: From lack of demand and/or obsolescence of equipment and process company will tender Government additional facilities and upon acceptance by letter and payment in cash to Government of fair value of improvements to fixed installations obligation of company on unpaid balance

of advance and interest ceases. Government can on default of production or other cause cancel contract and proceed to recover property.

(9) Force Majeure clause.

SUMMARY—TITANIUM METALS CORP. OF AMERICA

Proposed contract

(1) Quantity: 5,400 short tons per year for 5 years, or 27,000 tons.

(2) Government's advance: Not to exceed $10 million with interest at 5 percent per annum for construction of additional facilities.

(3) Advance repaid: On poundage payments of $0.22 for each pound of salable sponge produced from these additional facilities.

(4) Government's obligation to purchase: Not exceeding 5,400 short tons of titanium sponge (equivalent to 1 year's production) at any time over the life of the contract.

(5) Price: $5 per pound, $54 million.

(6) Specifications of sponge:

	Percent
Titanium (minimum)	99.5
Iron (maximum)	.15
Nitrogen (maximum)	.03
Chlorine (maximum)	.12
Magnesium (maximum)	.07
Carbon (maximum)	.05
Total impurities (maximum)	.5

Hardness, 170 Bhm.

Size 95 percent through ½-inch screen and not to exceed 1½ percent may pass a 20-mesh sieve.

(7) Sampling and analysis: United States Bureau of Mines methods and procedures.

(8) Obsolescence: In event of obsolescence of process or equipment the Government, if satisfied, may select to advance supplemental funds for replacements.

(9) Operating at a loss: If decline in market price or obsolescence of any equipment or process not replaced through Government advances result in inability of contractor to earn a reasonable profit and contractor so demonstrates to the satisfaction of the Government, contractor has the right to tender removable facilities to Government in full settlement of the remainder due upon the advance but must pay to the Government the fair value of nonremovable installations. The contract then will terminate and the Government has 18 months to remove the removable installations. If the contract is terminated for this reason the Government assumes the termination costs (settling power, raw materials, and labor contract costs) not exceeding $6,039,000. Government can, on default of production or other causes, cancel contract and proceed to recover removable property.

(10) Termination: In addition to termination when the contract quantities have been produced or sold to the Government, the contract will terminate when the contractor's profit after taxes but before amortization and other noncash expenses reaches 90 percent of the cost of the facilities ($9 million).

TITANIUM METALS CORP. OF AMERICA—REVOLVING FUND (EMERGENCY PROCUREMENT SERVICE) JANUARY 22, 1953

(1) Quantity: 1,250,000 pounds sponge entailing to December 31, 1953.

(4) Price: $5 per pound of sponge.

(5) Specifications of sponge:

	Percent
Titanium (minimum)	99.3
Iron (maximum)	.25
Nitrogen (maximum)	.03
Chrome (maximum)	.15
Magnesium (maximum)	.10
Carbon (maximum)	.05

Hardness 180 to 200 Brinel.

Size: 95 percent to pass ½-inch screen.

(6) Sampling, analysis and inspection: United States Bureau of Mines methods and procedures. Inspection Branch, GSA.

BUREAU OF MINES, BOULDER CITY, NEV., APRIL 30, 1953

(1) Quantity: 360,000 pounds of sponge over a period of 18 months.
(2) Government's advance: Total not to exceed $2,250,000.
(4) Price: Metal produced at actual cost plus 50 cents per pound allowance for maintenance and replacement. Cost per pound estimated between $4 and $4.50 per pound.
(5) Specifications of sponge:

Titanium, Iron, Nitrogen, Chlorine, Magnesium, Carbon, Hardness } Estimated percentage content of these elements will meet the specifications of industry.

Size: 95 percent to pass ½-inch screen and 1½ percent may pass 20-mesh.
Cancellation: Agreement terminated on 60-day notice by either party.

SUMMARY—CONTRACT WITH CRAMET, INC.

(1) Quantity: 6,000 short tons per year for 5 years, or 30,000 tons.
(2) Government's advance: Not to exceed $24,950,000 with interest at 5 percent per annum for construction of facilities.
(3) Advance repaid: Poundage payments on each pound of salable sponge produced. During first year of operation, total payments need not exceed contractor's profit after taxes but before amortization. If repayment is made on this basis, thereafter the poundage payment shall be the amount per pound determined by dividing the remainder due by the remainder of 30,000 tons to be produced.
(4) Government's obligation to purchase: Not exceeding 6,000 short tons of titanium sponge (equivalent to 1 year's production) at any time over the life of the contract.
(5) Price: For sponge sold to the Government during the first year of operation but not exceeding 1,000 short tons, $5 per pound. For the remainder, $4 per pound, both subject to escalation on $1.99 of cost and to any increase in royalty for use of Kroll process over that now fixed by the Department of Justice. Base total: $50 million.
(6) Specifications of sponge:

	Percent
Titanium (minimum)	99.5
Iron (maximum)	.15
Nitrogen (maximum)	.03
Chlorine (maximum)	.12
Magnesium (maximum)	.07
Carbon (maximum)	.05
Total impurities	.5

Hardness, 170 Bhm.

Size 95 percent through ½ inch screen and not to exceed 1½ percent may pass a 20-mesh sieve.
(7) Sampling and analysis: United States Bureau of Mines methods and procedures.
(8) Obsolescence: In event of obsolescence of process or equipment the Government, if satisfied, may elect to advance supplemental funds for replacements.
(9) Operating at a loss: If decline in market price or obsolescence of any equipment or process not replaced through Government advance results in operating losses, and contractor so demonstrates to Government's satisfaction, contract will terminate on 30 days' notice to Government, and Government is required to take title to facilities in full settlement of any remainder due he Government upon the advances. If contract is terminated for this reason the Government assumes termination costs (settling power, raw materials and labor contract costs) not exceeding $6,260,000. Government can on default of production or other causes cancel contract and proceed to recover property.
(10) Termination: In addition to the termination when the contract quantities have been produced or sold to the Government, the contract will terminate when the contractor's profit after taxes but before amortization and other noncash expenses reaches 90 percent of the cost of the facilities ($23,438,000).

E. I. DU PONT DE NEMOURS & CO., JULY 24, 1952

(1) Quantity: 2,700 short tons per year to a total of 13,500 short tons.
(2) Government's advance: Total not to exceed $14,700,000 with 4 percent interest for additional facilities.
(3) Advance prepaid: On poundage payments at $0.61 for each pound of sponge produced to continue until June 30, 1962, or until advances paid.
(4) Price: The lower of $5 per pound of sponge or average monthly market price of titanium sponge in which delivery is made.
(5) Specifications of sponge:

	Percent
Titanium (minimum)	99.3
Iron (maximum)	.25
Nitrogen (maximum)	.03
Chloride (maximum)	.15
Magnesium (maximum)	.10
Carbon (maximum)	.05
Total other impurities (maximum)	.70

Hardness, 203 Brinel.
(6) Sampling and analysis: United States Bureau of Mines methods and procedures.
(7) Obsolescence: Obsolescence of process and/or equipment if acceptable to Government the latter will advance supplemental funds for replacements.
(8) Operating at a loss: From lack of demand and/or obsolescence of equipment and process company will tender Government additional facilities and upon acceptance by letter and payment in cash to Government of fair value of improvements to fixed installations obligation of company on unpaid balance of advance and interest ceases. Government can on default of production or other cause cancel contract and proceed to recover property.
(9) Force Majeure clause.

E. I. DU PONT DE NEMOURS & CO.—REVOLVING FUND

(1) Quantity: 1 million pounds sponge extending to December 31, 1953.
(4) Price: $5 per pound of sponge.
(5) Specifications of sponge:

	Percent
Titanium (minimum)	99.3
Iron (maximum)	.25
Nitrogen (maximum)	.03
Chlorine (maximum)	.15
Magnesium (maximum)	.10
Carbon (maximum)	.05

Hardness 180 to 185 Brinel
Size 95 percent to pass ½-inch screen

(6) Sampling, analysis and inspection: United States Bureau of Mines methods procedures. Inspection Branch, GSA.

Senator MALONE. Now, General, I have in mind a letter of intent addressed to Titanium Metals Corp. of America, dated July 25, 1951, at the address of 60 East 42d Street, New York, N. Y.

There is one paragraph I should like to read.

The Government will advance to you from time to time as may be needed for the acquisition and installation of the additional facility for the necessary improvements, additions and alterations to existing structures amounts which may total, but not exceed, $15 million.

All advances will bear interest at the rate of 4 percent per annum on the unpaid balance from the date of advancement.

Do these other contracts substantially conform to that?

General METZGER. They substantially conform, other than the Bureau of Mines.

EXPECT MINOR PRICE REDUCTIONS

Senator MALONE. Of course. Du Pont will not exceed $14,700,000.

Then, General, at what point, in the volume of production of a company, just the same as making bricks or any other commodity where

there are certain fixed charges for other materials and for power, but where the labor and where the overhead and where a lot of other things can be stretched out over a larger production at a smaller unit cost, will this unit price of $5 per pound per sponge and $15 for rolled material be materially decreased?

General METZGER. Senator Malone, we have thought about that and discussed that among ourselves and in various meetings we have had on titanium, and we feel that there will be minor price reductions unquestionably within the next 3 or 4 years on the present basis, present method if nothing happens, to substantially reduce production costs.

There will be minor reductions in cost due to normal refinements and increase in learning in the plants, but we do not ourselves feel that it is imminent.

Senator MALONE. Well, possibly not imminent, but wouldn't the volume of production after the processes have been perfected have a considerable effect in lowering the cost?

General METZGER. Yes, it does, but I doubt that it has as much bearing or influence under a batch method as under a continuous method.

I think the costs are more apt to be firm and consistent after the learning cost, equipment writeoffs, and debugging costs have been eliminated. After that, then, there is more or less a steady position maintained.

Senator MALONE. Until you develop a continuous process method?

General METZGER. Yes. Or until competition would force a lower profit upon the producer.

Senator MALONE. Well, you are the competition. You know, after all, Congress would get inquisitive about that after a while and there might be a hearing held where it would embarrass everybody.

I am talking about procedures so that such a hearing would be unnecessary. All of the talk I have heard is that increasing the volume of titanium production would have some effect on the price. It did in aluminum and magnesium fields which we mentioned this morning.

When they were getting the bugs out of their production, it cost several hundred dollars a pound to start. Then, in World War II, it was $45 a pound, but now it is down to $15. What brought the price down from $45 to $15 a pound, General?

General METZGER. Well, I think it was a combination of increased volume, improved production and less costly production methods that brought that about, but I think in order to answer the titanium question, sir, that possibly we should look to the cost breakdown, the elements of cost, substantial elements of cost which enter into the final cost of the product.

Senator MALONE. That is very good; will you do that, please?

General METZGER. I can make a stab at it, but I would like to suggest that perhaps one of the producers give us that information. We know generally it is power.

Senator MALONE. We intend to go into that.

General METZGER. The cost of raw materials, labor and equipment amortization.

Senator MALONE. Do you have any approximate breakdown?

General METZGER. No; we have never been able to secure that cost information. It is our opinion that the cost of raw materials is perhaps the major cost, but we can't be very specific about it.

Senator MALONE. Well, there will be certain fixed costs. There will be a charge for power. If it takes 20 kilowatt-hours per pound and it costs a half a cent per kilowatt-hour, you would have 10 cents for power. You couldn't reduce that.

General METZGER. No, sir.

Senator MALONE. Still that is only 10 cents and you are selling at $5 a pound.

General METZGER. Well, $5 selling price, sir.

Senator MALONE. Well, we are selling at $5.

General METZGER. Yes, sir.

Senator MALONE. Let's see what the difference is. You have certain raw materials?

General METZGER. You have magnesium and rutile present.

Senator MALONE. Your raw materials are coming from Australia now?

General METZGER. Yes.

Senator MALONE. Do you have any idea what the cost of rutile from Australia is?

General METZGER. No, sir; I don't know.

Senator MALONE. Would you name the raw materials and the ingredients going into this sponge, as you know them?

General METZGER. All of them?

Senator MALONE. There is chlorine?

General METZGER. Chlorine, magnesium, and the ore. I believe those are the principal ingredients. Of course, there are the gases, creating an inert atmosphere.

Senator MALONE. Wouldn't it be reasonable to suppose that not too much additional overhead would be necessary except for labor, and some other ingredients if you were turning out maybe a hundred tons a day instead of 10 tons a day?

General METZGER. There is a point there where overhead burden can be spread effectively and economically, resulting in a reduced cost; that is very true. There is also a limit, I believe. I personally think it is probably the materials, and I feel that the cost today of sponge is in the neighborhood—that is, the cost to the producer is in the neighborhood of $3.50, $3.60, or something like that. With probably the raw materials making pretty close to half of it. I don't know.

This is purely conjecture on my part, Senator Malone.

COMMERCIAL USE

Senator MALONE. Eventual commercial use of titanium would probably consume a larger part of titanium production than national-defense consumption. What would the price of titanium have to be in order for titanium to be used in commercial planes?

I have just ascertained by inquiry, without any real investigation, that it would mean perhaps a 30-percent additional payload.

General METZGER. That is about right, sir. It is profitable today to the carriers, commercial carriers, to engineer titanium for weight-saving purposes.

Senator MALONE. Even at $15 a pound?

General METZGER. Yes, sir.

Senator MALONE. That is a very important statement. I rather thought they might be holding back on account of price as well as availability, but you don't think so?

General METZGER. Not with the increase in payload. I believe it is a paying proposition for them right now. Now, there is a limit to which they naturally would go.

There is always an irreducible minimum, but whether you—well, I think we have one carrier here who would like to put it in a new aircraft he is building. We have the figures which were presented to us, furnished us by Douglas Aircraft on the DC–7 airplane, which is the followup to the DC–6 that most people know about, for long-range, four-engine aircraft, which could be utilized.

There are certain applications in the engine nacelles, firewall, and a few other applications, which are reducing the weight of the aircraft approximately 200 pounds.

That was their original statement. It is actually turning out to reduce the weight closer to 300 pounds, and this is equivalent to 1½ passengers for the entire life of the airplane, so it is really a bargain for them.

We feel, and I believe they will agree also, that it would be a bargain at 20 per pound.

Senator MALONE. Well, if 300 pounds of weight could be saved, much more titanium would be used if it were available at the present price.

General METZGER. I know that is true because considerable quantity is required or desired for the super-Constellation, particularly in the engine nacelles, but that has not been available.

Senator MALONE. If they had a 30-percent more payload, it would mean, on a 60-passenger plane, 54- or 60-passenger plane, instead of 60 passengers that same plane could carry 80 passengers.

General METZGER. Yes.

Senator MALONE. That would begin to run into real money.

General METZGER. It isn't always the number of passengers it would carry.

Senator MALONE. It is the weight.

General METZGER. It is the fuel that they could probably carry and still make certain weather alternates. We will just assume this will be one consideration.

There are probably others, other than increasing the size of the aircraft in order to put passengers in. As we all know, the CAA regulations require certain weather alternates be maintained. Under certain weather conditions, fewer passengers will be carried, but more fuel will be carried.

If you have a lighter aircraft, you can transfer the saving either to passengers or to fuel, and you end up with more passengers, is what you do.

Senator MALONE. And end up with more pliability and more latitude in operations.

General METZGER. So I think that is pretty generally what we are talking about, when we say it means 1½ or 1¼ more passengers.

Senator MALONE. The purpose of these questions, of course, is to determine whether or not there is a present demand for a large amount of titanium; what amount might be used at the present price?

General METZGER. That is right.

Senator MALONE. Well, aren't you passing the 100,000 pounds per year pretty quickly if you get into commercial production?

General METZGER. You could, and again, sir, that would depend upon how many commercial aircraft they manufacture and can sell. I don't know how many they will produce.

Senator MALONE. But it would make the present type planes obsolete as soon as new planes containing titanium could be constructed?

General METZGER. To a degree it does, although the obsolescence of commercial aircraft is sometimes difficult to understand when you see DC–3's still flying over this country over mountainous terrain.

Senator MALONE. You have had no difference in the weight, however.

I started to ride planes in 1926 or 1927 when there were just 2 of us sitting behind the mail. These planes now, some of them have been running for 15 years. But you have had no great departure in availability of lighter and stronger materials, have you?

General METZGER. Not particularly, although there has been a wide departure from the performance speed, passenger-carrying ability of aircraft since World War II.

Senator MALONE. But you haven't been able to lighten the weight.

General METZGER. No, sir.

Senator MALONE. This would be a revolutionary thing?

General METZGER. I believe, Senator Malone, that the question would be resolved by the economics as viewed by the air carriers themselves, whether or not they could afford it, whether it would pay off for them to turn out some of the older aircraft and replace them with new.

As we have read very recently, most of the carriers are still operating at least under a subsidy, as far as airmail is concerned, and they may not be in position to buy any substantial quantity of new aircraft, regardless of how improved the characteristics may be, or how much more revenue they would gain. That is the biggest problem.

Senator MALONE. Yes; and for your information, General, we do intend to have the producers of commercial planes appear before the committee.

I thought maybe some of them would be here today, but they do not seem to be present.

Well, then, in summing it up, the real bottleneck is the availability of the material in the national defense field at the moment?

General METZGER. The availability of the material both in quality and in quantity. The quality should be improved. That will help the quantity, and by all means, we need more of it.

Senator MALONE. From the experience of the Cramet Co. in trying to find power, and the experience of other companies, power is a contributory factor to the bottleneck?

General METZGER. It is one prime consideration in the field that should be given to expansion, the availability of power.

Senator MALONE. General, the committee appreciates very much your appearance here.

Do you have any further statement you would like to make at this time, or any material you would like to submit for the record?

General METZGER. No sir; I don't have. I would like to state for the record it is a privilege to be here, and a privilege to present the military aircraft position and thinking on this very vital subject.

Senator MALONE. General, we have a brief prepared by you, entitled "Titanium and Its Significance to American Industry and to the United States Government, by Brig. Gen. Kern D. Metzger, Chief, Production and Resources Division, Directorate of Procurement and Production, Air Materiel Command, United States Air Force, with Headquarters at Wright-Patterson Air Force Base, Ohio."

Do you approve making it a part of the record?

General METZGER. Yes, sir, that is perfectly agreeable.

Senator MALONE. When was this brief prepared?

General METZGER. I would say March 1953.

Senator MALONE. That will be submitted for the record at this point as a part of General Metzger's testimony.

(The brief referred to is as follows:)

TITANIUM AND ITS SIGNIFICANCE TO AMERICAN INDUSTRY AND THE UNITED STATES GOVERNMENT

By Brig. Gen. Kern D. Metzger, Chief, Production and Resources Division, Directorate of Procurement and Production Air Materiel Command, United States Air Force

TITANIUM

With the announcement of commercial production of titanium, a new metal system joined the ranks of our useful structural metals.

Certain characteristics of titanium bid fair to make it a potentially important metal for the future—namely, it is light, strong, durable, and corrosion-resistant.

To these we might add one other important qualification—it is plentiful.

Admittedly, we still speak today in terms of potentialities of titanium and its alloys, but potentialities are rapidly becoming realities.

Even at today's stage of development, titanium is assuming a prominent position in the structural metal field and is no longer classed as a rare metal.

Much of the glamour has worn off "titanium." Today the metal is tarnished with a host of problems, all the way from sponge making to eventual use as a fabricated part. The technical and engineering problems, while difficult, are no more perplexing than other commercial problems in the history of metal development.

Many high-powered words have been written—for and against titanium—a metal new to some industries. Its champions are enthusiastic with praise. Others say titanium, with all its advantages, is a troublesome metal to fabricate and much too costly.

In its short life titanium has been tagged "The new wonder metal," "Glamor metal," "The middleweight champion," and now—just another metal.

WHAT IS TITANIUM?

Titanium is (*a*) a silver grey metal weighing 0.16 pounds per cubic inch, (*b*) 60 percent heavier than aluminum, (*c*) 56 percent lighter than alloy steel, (*d*) its alloys are far superior in strength-weight ratio to all usual engineering metals and alloys.

There is little doubt titanium will be our next major structural material. Its development foreshadows immediate advancements in supersonic aircraft, rocket, and gas turbine design—and foreseeable improvements in thousands of other industrial and consumer products.

This metal promises possible application potential equal to that of stainless steel and perhaps rivaling that of some of the lighter metals.

There are several good reasons for such optimism. Titanium is plentiful. It ranks as fourth most abundant structural metal in the earth's crust. Only aluminum, iron, and magnesium are present in greater percentages.

Its corrosion-resistance is equal to platinum and greater than that of nickel, stainless steel, and the cupro-nickel alloys in sea water and other corrosive fluids.

On an equal-strength basis, titanium weight is less than that of aluminum or magnesium.

ELECTRICAL CONDUCTIVITY

Titanium has relatively low electrical conductivity and is nonmagnetic.

Titanium possesses an unusual combination of intrinsic properties; in fact, the scope is so promising in the aircraft industry, that all indications point to it becoming a most prominent structural metal when certain production problems are overcome.

To 1950, titanium was used only experimentally but is now rapidly moving into territories once exclusively occupied by stainless steel.

HISTORY OF TITANIUM

In 1791, over 161 years ago, there was knowledge of the existence of titanium. An Englishman, William Gregor, clergyman and amateur chemist, noticed the black magnetic sands of Cornwall contained 50 percent of an unknown white metallic oxide. Some time later this was confirmed by an Austrian named Klaproth, who succeeded in extracting the metal from the ore rutile, at which time it was named titanium. The name came from the mythical "Titans—Sons of Earth."

TITANIUM IN AMERICA

Titanium success in the United States came in 1908 when Rossi and Barton successfully managed to separate a useful form of the oxide from the ore, while working for the Titanium Alloy Manufacturing Co. During the period 1921 to 1925 a process was developed whereby straight titanium dioxide was successfully produced. This same period (1925) saw small batches of high purity titanium metal made. The basic process for production of titanium as it is known today was developed by Dr. William Kroll. He started his first experiments in Luxembourg.

In 1932 Dr. Kroll succeeded in reducing titantium tetrachloride with pure magnesium in a molybdenum-lined electrically heated crucible. In 1939 Dr. Kroll came to the United States and was employed by the United States Bureau of Mines. In 1946 the United States Bureau of Mines released Bulletin No. 7381, Metallurgy of Titanium and Its Alloys. It was one of the first (if not the first) major publication or report on titanium.

That same year the United States Bureau of Mines started operating a pilot plant, using the Kroll method, producing 100-pound batches of totanium sponge which launched the titanium industry of today.

In 1946, P. R. Mallory & Co., Inc., started their research work.

In 1947 Remington Arms began their program on melting, alloying, and fabrication.

In 1948 (August) Remington Arms became the first industrial organization to announce its commercial interest in titanium as a metal.

It was in 1948 that Du Pont opened a small pilot plant for limited production, producing 160 pounds of metallic titanium per day, or approximately 30 tons per year.

In 1950, for the first time, titanium metal was offered on the open market in a wide range of fabricated products, such as large plates, bar, forgings, tubing, and wire. However, producers of titanium sponge, ingot, and finished products were not able to keep up with the heavy demands for strategic and experimental application.

TITANIUM ORES

Titanium exists in a combined state in different forms and one-sixteenth of the earth's crust is titanium-bearing ore.

1. Rutile is a high-grade titanium oxide with very few impurities.
2. Ilmenite is a lower grade combination of titanium oxide which is more common than rutile.

Titanium ores are found extensively throughout the United States, Canada, India, Australia, Norway, Ceylon, Brazil, Sweden, and the U. S. S. R. Large ilmenite deposits of titaniferous iron ores occur in New York, Minnesota, Rhode Island, Wyoming, California, and New Mexico. Other occurrences of iron ores rich in titanium have been reported in North Carolina, South Carolina, Tennessee, New Jersey, Colorado, Montana, and Oklahoma.

Rutile is found in the beach sands at many places along the Atlantic, Pacific, Redondo Beach, Calif., and gulf coasts. They have been worked mainly in

Florida and to some extent in Oregon. Rutile deposits also occur in Virginia and Arkansas.

The United States Bureau of Mines estimates that at Allard Lake in eastern Quebec there is 300 million tons of ilmenite containing titanium oxide. It is estimated that 25 million tons of titanium metal can be produced from this source alone.

Supply of titanium ore can be summarized as follows:

1. Availability will present no problem as known deposits of titanium-bearing ore reserves will amply supply the industry far into the foreseeable future.

2. Large deposits are available in the North American Continent. In the event of an all-out war, the United States would not be dependent on highly vulnerable sea transportation for titanium ore.

3. Even at the current low rate of production, titanium ore is not expensive. Current price is now 2 to 6 cents per pound, but with increased demand and mining efficiencies this price will drop.

PROCESSING ORE TO SPONGE

Several methods may be employed in transforming titanium ore into metallic form. Today all ore "batch methods," however, and not "continuous line methods."

Much effort is being expended by industry and Government to develop an efficient method of titanium sponge production by a continuous line operation.

Kroll process: About 99 percent of today's commercial titanium production utilizes the modified Kroll process developed by the United States Bureau of Mines.

In this process titanium tetrachloride, produced by chlorination of titanium ore, is reduced to the metallic state (usually with magnesium) in an inert atmosphere.

Next, the magnesium chloride and excess magnesium are removed, leaving behind a relatively pure titanium metal, in a grey, porous, cokelike mass known as sponge titanium.

Approximately 1 pound of magnesium is required for every pound of titanium obtained.

The entire operation is carried out in a chemically inert atmosphere of helium or argon gas. This is to prevent the titanium from absorbing oxygen, nitrogen, and hydrogen contamination from the atmosphere. Titanium is an unusually active chemical substance. In a molten state it readily combines with any material it contacts.

MELTING SPONGE TO INGOT

Melting: Sponge titanium must be converted into a more useful form. It has no commerical value in its porous state. The following general techniques have been developed for transforming the sponge into a solid ingot.

1. Continuous arc melting process: Consists of the continuous casting of the molten sponge followed by solidification of the molten metal in a water-cooled copper mold.

2. Induction melting process: The utilization of the heating effect of induced electric current. The entire process must be carried out under a protective atmosphere to prevent gas absorption.

3. Herres process: Now being developed by Titanium Metals Corp., Henderson, Nev. It is an improved cold mold method, using multiple electrodes.

Ingots: Titanium Metals Corp., Henderson, Nev., have successfully made ingots up to 2,742 pounds and Rem-Cru now makes a 4,000-pound ingot.

Forming: After converting the sponge into a solid titanium ingot, the ingot must be machined or "scalped" to remove all surface defects. In the next step the ingot is heated to approximately 1,800° F. and hot rolled or forged into a useful form for use by the fabricator.

Titanium can be processed from the ingot to semifinished form by using the same rolling equipment and methods used for processing stainless steel.

Electric power plays a most important part in today's production of titanium sponge.

More electric power is required to produce titanium than is required to produce an equivalent amount of aluminum or magnesium. The present shortage of power and the possibility of getting supply in balance with demand are of vital interest.

Both magnesium and chlorine are electrolytic products; however, the electrolysis of magnesium chloride produced in the titanium extraction process returns most of the magnesium used, but only about 60 percent of the chlorine. Electrical heating required both for processing and melting the metal adds to power demand. Totaling these power requirements points out that the production of titanium consumes about twice the power needed to produce aluminum or magnesium.

20 kilowatt-hours are required to produce 1 pound of titanium sponge. Requirements to produce 100,000 tons are—

4 billion kilowatt-hours.
240,000 tons ilmenite.
450,000 tons chlorine (regeneration facilities).
110,000 tons magnesium (regeneration facilities).

It is an economic law that ore be brought to the power and never power to the ore. The cost of power doubles for each 400 miles of transmission. The titanium production industry must, of necessity, locate only where an abundance of low mil rate electric power is available.

The power needs of the Titanium Metals Corp. plant at Henderson, Nev., have taken up the last large supply of surplus hydroelectric power in this country.

The present shortage of electric power and the problem of getting power supply in balance with demand are of vital national interest.

Drought conditions and low river levels in the Northwest have greatly aggravated our already critical power shortage in that area.

THE TITANIUM INDUSTRY

Industry is currently spending millions of dollars each year on all phases of titanium research. Similar to aluminum and magnesium, which 60 and 45 years ago cost $5 a pound, it is expected new or improved processes will eventually be developed to reduce the present high cost of titanium.

Production of titanium sponge in 1951 was about 500 tons coming from plants operated by—

1. E. I. Du Pont de Nemours.
2. Titanium Metals Corp. of America.
3. Crane Co. at Chicago, Ill.

The Titanium Metals Corp. plant is the former Basic Magnesium, Inc., plant at Henderson, Nev., built by the Government during World War II. Major components of this plant were leased from the State of Navada. Power is allocated from Hoover and Davis Dams from the quota alloted to the State of Nevada. The Henderson plant is the only fully integrated titanium plant with facilities for chlorination of titanium ore and recovery of magnesium and chlorine. Initial operation at the Henderson plant began in September 1951 and routine production started in October. Capacity production of 10 tons per day expected in the second quarter of 1953.

Du Pont began operating a commercial plant in May 1951 with a capacity of 2 tons of titanium sponge per day. The production rate originally estimated was reached in 1951. Du Pont reached a capacity of 2½ tons per day at this plant in 1952. At the request of the Government, the General Services Administration had negotiated with Du Pont for additional expansion in 1953–54. Du Pont does not recover the magnesium or the chlorine.

The National Research Corp. of Cambridge, Mass., and Monsanto Chemical Co. joined forces to develop an improved process for the production of titanium. Work already in process by National Research was expanded and additional work was initiated by Monsanto's research department at Dayton, Ohio. P. R. Mallory & Co. and the Sharon Steel Corp. formed the Mallory-Sharon Titanium Corp. for the development, production, and marketing of titanium and titanium alloys. A new process for producing titanium metal is under investigation by Horizons Titanium Corp., a new firm formed by Horizons, Inc., of Princeton, N. J., with the backing of Ferro, Inc. of Cleveland, Ohio, and others.

The research process developed by Horizons, Inc., under the sponsorship of the Office of Naval Research, advanced to the pilot plant stage in 1952. The Kennecot Copper Corp. after investigating several processes during the past several years, have developed a process on a laboratory scale, which shows possibilities of producing superior quality metal with certain production advantages over present processes. A pilot plant to evaluate the process on a scale of about 200 pounds per day was under construction at Battelle Memorial Institute in 1951 and is expected to be in operation in 1953.

The Glidden Co. and Bohn Aluminum & Brass Corp. have decided to pool their titanium research efforts. Both companies are interested in production of pure metal, its compounds, and alloys, as well as in fabrication of ductile titanium and alloys. Glidden owns ilmenite-bearing deposits in North Carolina and has operated a mine there for the past 10 years. Research will be carried on at Glidden's research laboratories in Baltimore and at Bohn's laboratories in Detroit, Mich.

Metal Hydrides, Inc., Beverly, Mass., produced 144,271 pounds of titanium powder in 1951 by reduction of titanium oxide with calcium hydride. Titanium was supplied by Metal Hydrides as powder, titanium hydride, and titanium master alloys. The titanium powder is reported to be easily compressed into suitable forms and sintered either in vacuum or in a nonoxidizing atmosphere into solid blocks or finished products at as low as 900–1,000 degrees C.

The Foote Mineral Co., Philadelphia, Pa., installed capacity for the production of extremely pure titanium by thermal decomposition of volative titanium iodides. They offer for research purposes, titanium crystal bar, 99.99 percent titanium, approximately ½ inch diameter by 19 inches maximum length.

AIR FORCE POLICY

An active and strong Air Force policy covering utilization of titanium has been formulated and put into action. The Air Force titanium program is giving stimulation to industry to bring about a lower price, improve titanium qualities and characteristics, increase production and sustain the interest of companies presently active in the titanium field.

The Air Force policy regarding titanium

1. Advise other Government agencies, including the Defense Materials Procurement Agency, of Air Force interest in this metal.
2. Encourage the titanium industry in its efforts to expand production and improve quality.
3. Continue basic and applied research necessary in furthering the program, including the development of production know-how with aircraft and engine manufacturers.
4. Support Air Force contractors in their efforts to use titanium by allowing for a fair share of the increased costs encountered.

In support of these objectives the Air Force recently announced to contractors that it will accept a fair share of increased costs incurred through the use of titanium. By paying premium prices even for marginal uses certain current advantages accrue. However, much larger dividends may ultimately be gained through improved design and engineering. Air Force support insures a substantial decline in price.

The Air Force recently issued three CCN's (Change Contract Notice) that authorized Convair to incorporate titanium in production quantities in the B-36. Similarly, other Air Force contractors have and will be authorized to use titanium in existing production items in the future. This will permit contractors to develop the necessary manufacturing skill and know-how to be reflected in the design of future models.

Titanium is needed in engines, airframes, and pilotless aircraft or guided missiles. It is needed not only in complex area and major components but also in such simple forms as bolts and nuts. Wherever weight can be saved and the saving translated into greater range or increased payloads—titanium is needed. To satisfy these needs, titanium will be required in forgings, sheet, bar stock in all sizes and shapes. It must have the properties of strength and heat resistance with good structural characteristics. The point is it must be versatile and adaptable to many applications.

AMC PROGRAM—TITANIUM COMMITTEE

A titanium committee has been established and functions at Headquarters Air Materiel Command to insure that titanium be used to the maximum extent practicable.

Committee membership includes representatives from:

1. Aircraft Production and Resources Agency.
2. Air Research and Development Command.
3. Air Materiel Command.
4. Other interested segments of the Department of Defense.

The committee, under jurisdiction of the Production and Resources Division, Directorate of Procurement and Production, AMC, undertakes to assure the following Air Force actions:

1. Coordinate Air Force activities regarding titanium.
2. Recommend actions to encourage maximum efficient utilization in aircraft production programs.
3. Serve as focal point for collection and dissemination of technical information to industry.

Even now, the committee has been largely responsible for formalizing Air Force titanium policy. In addition, it has given recognition to the need for titanium in current aircraft production.

Industry can expect to be requested for some serious thinking relative to efficient production and use of titanium.

Titanium development may well be financed by the Government but must, of necessity, be accomplished by industry.

MUNITIONS BOARD COMMITTEE

The Munitions Board recently recognized the need for a high level policy committee in the Department of Defense to expedite the development and use of titanium. This committee is currently being appointed with membership selected from general and flag officer rank. The committee's responsibility will be the formulation of Department of Defense policy relative to procurement, development, financing and use of titanium in military equipment. This will allow the budgeting, procuring, and production organizations of all three military departments to move more freely and rapidly into the adoption of titanium as a standard production material.

DEFENSE MOBILIZATION COMMITTEE

The need exists for a similar committee at the level of the Office of Defense Mobilization to permit discussion and formulation of policy decisions at the highest levels of Government. Such a committee has already been informally discussed, and it is hoped that some constructive action will be taken in the near future.

TITANIUM COST VERSUS ALUMINUM

Considerable is said of the cost of titanium.

Let us take a moment to look back at the progress of aluminum.

In 1852—100 years ago—aluminum was so costly to produce it sold for $545 a pound and was more precious than gold or silver.

Emperor Napoleon III was presented with the first aluminum, in the form of a medal.

Later Napoleon's honored dinner guests had place settings of forks and spoons of aluminum—lesser guests found only gold and silver service at their plates.

Over 60 years ago a small portion of the pyramid of the Washington Monument was capped (and still is) with aluminum.

In 1885 the price was $11.13 per pound and in 1892 it was 57 cents a pound. Seven years later it was 23 cents per pound and in 1952 it reached a low of 14 cents.

Modern invention, coupled with free enterprise combined to bring aluminum within the reach of everyone.

Secretary of Defense Lovett recently made the observation "when 1 pound of weight is added to an airplane, 10 pounds must be added to the structure cost."

Figuring the overall cost of the modern airplane at $40 a pound, 10 pounds would represent $400.

When the relationship of weight to cost is considered, titanium has a definite edge economically. The strength-weight advantage, plus the relative low-cost bonus makes titanium highly desirable for use in commercial and military airplanes and airborne equipment.

In time of high demand, as during the last war, there is not enough chromium and nickel to meet all requirements for stainless steel. Titanium promises to play an important part in conservation of such vital metals.

Titanium, when alloyed with a small amount of chromium, aluminum, manganese, oxygen, nitrogen, or iron, is many times stronger than unalloyed titanium and still retains most of its corrosion resistance.

The amount of chromium needed to produce corrosion resistant titanium is only about one-sixth of that required for stainless steel.

The Air Force wants titanium and titanium alloys in aircraft. It will readily lend its support to any justifiable program aimed at achieving these objectives.

II. CLOSING REMARKS

During the past, the United States Air Force and American industry have worked together as a team to build the greatest Air Force in all history.

It was a remarkable job which required the closest kind of cooperation, and it clearly indicates how much can be accomplished under the American system when we all put our shoulders to the wheel.

We are now building for national defense, and it is important that we again work closely together. For this reason, I particularly welcomed this opportunity to talk to you.

It provides the opportunity for a review and discussion of the titanium programs under way and should stimulate and encourage the application and utilization of this new metal which shows such great promise.

Certainly—timely advice to all industry—is to alert and familiarize your organization with the many applications and machinability of this metal—titanium.

Thank you very much, General.

I will have to warn you that this probably is not your last appearance before the committee, but I hope you won't have to travel so far next time.

General METZGER. Thank you, sir.

(Witness excused.)

Senator MALONE. We will take a short recess.

(Recess taken.)

Senator MALONE. The committee will be in order.

We will hear next from the Bureau of Mines.

I may be confused as to who is really in charge of the work. Mr. Mastin, are you the director?

Mr. MASTIN. Mr. Lloyd is in charge of the station at the Bureau of Mines.

Senator MALONE. Mr. Lloyd, will you come forward.

TESTIMONY OF REX R. LLOYD, BRANCH CHIEF, BUREAU OF MINES, BOULDER CITY, NEV.

Senator MALONE. What is your title, Mr. Lloyd?

Mr. LLOYD. Chief of the Electrometallurgical Branch, which is the Boulder City station.

Senator MALONE. If you would like to have Mr. Wartman and Mr. Mastin come forward, you may do so.

Will you identify these gentlemen, please?

Mr. LLOYD. Mr. Wartman is Chief of the Titanium Research Section in Boulder City, and Mr. Mastin is Chief of the Titanium Development Section.

Mr. Wartman is in charge of all basic research, and Mr. Mastin is in charge of the pilot plant, and any operations of a larger scale.

Senator MALONE. Mr. Lloyd, you have heard the testimony of Brigadier General Metzger about the demand for titanium, and the production of titanium by the Bureau of Mines.

Will you, in your own way, explain just what the Bureau of Mines is producing at the present time? Further, the committee is very

much interested in the contribution you are making in trying to develop a continuous process to take the place of the batch process, and any other investigations or laboratory work under way.

Mr. LLOYD. Well, it might help if I explain a little bit what the development is, and the way the work has gone at Boulder City.

The plant work was first started at Boulder City in 1944. The original laboratory work was moved down from Salt Lake City to Boulder City, and in 1944 a pilot plant was started.

Senator MALONE. What was the size of the pilot plant?

Mr. LLOYD. The first reaction pots were 100 pounds. We didn't aim for any regular production because it wasn't so much what we produced each day, but how much we produced and were still able to keep up the quality of the metal.

Senator MALONE. Or how much you could produce at all.

Mr. LLOYD. Yes, sir. The first 100-pound batches were made in December of 1944. We published a report on that, and that was really the work that started the industry to be interested in titanium.

We did go up to 200-pound batches just to show that we could enlarge the rate of production, by the 16th of January in 1948.

I may have to look back to find the exact date, but sometime in 1950 we entered into a contract with Army Ordnance to develop a continuous reactor. At that time it was decided that the smallest continuous reactor we could make was about a ton a day of sponge.

We built a pilot plant or demonstration plant with that capacity. It wouldn't have been necessary to put in purification equipment for that capacity, but the shortness of titanium at the time, and also the very high cost of the material, made it desirable to recover the titanium and not just throw it out the door when we spoiled any of it.

We never have to date got a continuous reactor in operation that could produce anything like that. Later on we did operate the plant for nearly a year—well, for a year for Army Ordnance—and incidental to that operation we did produce about 5 tons of metal a month.

That was during the 1953 fiscal year. Last May, the 1st of May, we entered into a contract with DMPA. The only purpose of that contract was that the amount of titanium that was being produced was way short of the requirements.

The Defense Materials Procurement Agency wanted to utilize our capacity to the extent that we thought was possible without interfering with the research program.

The plant was originally designed for 1 ton a day, but after some experience we decided that about 20 tons a month was the maximum we could produce without interfering with the research program.

As I say, that program was entered into in May and we started to produce on that in June. This month we will produce about 15 tons. We are not yet up to the 20-ton capacity.

That is an 18-month contract, and, of course, it is anticipated that the contract will not be renewed unless the demand is so great at that time that it is decided to, as a matter of policy, go ahead with it because, as you know, Senator, the Government doesn't usually get into business.

Senator MALONE. Well, your capacity is 18 tons?

Mr. LLOYD. Eighteen tons.

Senator MALONE. Eighteen tons a month?

Mr. LLOYD. About 20 tons a month is what we anticipate.

Senator MALONE. About two-thirds of a ton a day.

Mr. LLOYD. Yes.

Senator MALONE. And do you find that you can come up to your production without interference with your laboratory work?

SHORTAGE OF SKILLED TECHNICIANS

Mr. LLOYD. Well, that is a little hard to say. We are producing up to 15 tons a month now. It is interfering, to a minor extent, with our laboratory work because of the extreme shortage of skilled, technical men available. We are having a hard time maintaining the staff.

Senator MALONE. Why?

Mr. LLOYD. There are several reasons.

Of course, as everybody knows, technical men are in very short supply. Government wage scales are not competitive with private industry in this particular area, and Boulder City especially, where the housing situation is very bad.

It makes it difficult to draw men to this area and to maintain the staff when we do get the work.

Senator MALONE. What is the difference, roughly, in the commercial pay and the pay in the Bureau of Mines for the same type of technical assistance?

Mr. LLOYD. For starting technical men, which are after all the men we need, we need to be able to compete with industry, and with men just coming out of school, that is one of the places we are particularly in an unfavorable position. I think there is something like $1,000 a year difference in starting salaries, and up.

Senator MALONE. What is your pay?

Mr. LLOYD. We start the men at—I don't know the exact figure—but about $3,100 a year.

Senator MALONE. And roughly, the commercial pay is $4,000 or $4,100?

Mr. LLOYD. $4,000 and on up to $5,500, depending on how good the man is and how badly they want him.

Senator MALONE. And they can advance him as far as they want to, whereas you are held down to a certain time of service?

Mr. LLOYD. Yes; we are held down to a certain time of service. However, good men normally do advance fairly rapidly in our organization, but again, they can only advance to about $5,060 a year, within a year and a half or 2 years.

Above that it takes specialists or men in a supervisory capacity, or something like that. Again, we can't compete with industry.

Senator MALONE. You have to change their rating?

Mr. LLOYD. We have to change the rating.

Senator MALONE. To go above that amount?

I understand that. Now, go right ahead.

Mr. LLOYD. Of course, in Boulder City, as everybody knows who has been following the situation, the housing is very bad and rentals are high.

Quite often we do somehow manage to get people in here and they work a month or two and quit and go back to some other area they are more familar with.

Senator MALONE. I am somewhat familiar, not with the shortage of housing in Boulder City, but in the changeover proposed from Government jurisdiction to private jurisdiction.

I did send a proposed outline for a bill prepared by the Bureau of Reclamation to the chamber of commerce and other individuals for their comments and suggested amendments. So far I have not received them.

Mr. LLOYD. We are very familiar with what is in that proposed bill.

Senator MALONE. I was not aware there was a severe housing shortage. What causes the housing shortage, lack of sufficient ground upon which private homes can be constructed?

Mr. LLOYD. Yes. At the present time there are no lots at all available in Boulder City for the construction of residences.

Senator MALONE. Where water and service are available?

Mr. LLOYD. Where there are water and sewage and power.

The last lot, some time ago, has been taken up and is being built on at the present time.

Senator MALONE. The city is just outgrowing plans.

Mr. LLOYD. That is right; the city outgrew the plan, and as I understand it, in talking to the city manager, the difficulty of trying to get developers is that the Government would have to furnish the power.

Of course, the sewage capacity is somewhat limited, although it does have some additional capacity. The town is just bigger than it was anticipated it would be, and no provision has been made for expansion.

Senator MALONE. We are very much concerned that your laboratory work not be interrupted because that work has great possibility of improving the batch process or perfecting a continuous process.

Mr. LLOYD. We are still continuing work on continuous processes, and that particular phase of the work is Mr. Wartman's basic research.

Senator MALONE. You always fall back on Mr. Wartman?

Mr. LLOYD. Yes; he is the man responsible for the new advances.

There is one other thing that has come to the fore that perhaps we did not anticipate far enough in advance, and that is the difficulty of making titanium tetrachloride, which is the raw material used at the present time for making titanium.

Senator MALONE. This is in the Kroll process?

Mr. LLOYD. This is in the Kroll process and in quite a lot of the proposed electrolytic processes, too.

Titanium tetrachloride was available on the market, rather expensive material, when we started to make titanium. Since it was available we did no research, or at least very minor research on titanium tetrachloride.

Last year we bought from a commercial company. They were producing from pigment titanium dioxide. However, it is obvious that some research work should be done on titanium tetrachloride, and particularly on other raw materials besides rutile.

This work was started up along with the rest of the work for Army Ordnance a year ago April; that would be April of 1952. That work is dragging to some extent because we can't get additional technical people we should have.

Whether or not the technical people we have working in our production plant, at least in our pilot plant, are adaptable to that type of work is another question.

Senator MALONE. What do you think?

Mr. LLOYD. I think only to a minor extent.

Senator MALONE. Then you would say right now, your production is only interfering to a minor extent with your laboratory work, your search for new methods and perfection of present methods.

Mr. LLOYD. I might say this, Senator——

Senator MALONE. In the manufacture of the product.

Mr. LLOYD. We like a certain amount of production because it helps with our research problems.

Originally we anticipated that would be at the scale of about 20 tons a month, the point at which production starts to interfere with research. There may be some of the men who are now working on production that could be transferred over into research, and with reasonable service, you understand that it takes a little different type of man to do research than it does to do production.

I would like to ask Mr. Mastin's opinion, since the titanium tetrachloride and development work is in his supervision.

Mr. MASTIN. I agree with Mr. Lloyd on that. The men that we have that are actually producing titanium are better suited for that kind of work than any other kind of work, and while they could be trained eventually to do reasearch work, it would be a slow program.

Senator MALONE. When you say slow, you mean 6 months or a year?

Mr. MASTIN. A year or 2 years. We should be able to obtain preferably chemical engineers and chemists for that kind of work, whereas now we have metallurgists who happen to be production minded and serve very well in that niche.

Senator MALONE. Yes. Most engineers and producers and builders understand there is a great difference between men who use the processes for production and men who develop the processes.

They are just an entirely different type of men, mentally as well as physically often.

Go right ahead.

Mr. LLOYD. I might say there is no serious shortage at the present time in this area of craftsmen, mechanics and laborers, operators to operate these plants.

The shortage is almost entirely in technical men. It has been brought out, I believe, that we really need new technical men from the outside who are research minded, or with a research background.

Senator MALONE. And with research experience?

Mr. LLOYD. Preferably with research experience.

Senator MALONE. Would they be available at all until you could meet, or approach what they could earn elsewhere?

Mr. LLOYD. That is correct; they are not reasonably obtainable under the present wage scale and under the present high living cost and high rent in the Boulder City area.

Senator MALONE. Are they available if you meet reasonable commercial competition?

Mr. LLOYD. Well, of course, the scarcity of technically trained people is well known. It is prevalent everywhere. Naturally, we could stand a better chance of getting our share.

However, in this day and age there is not a large number of highly skilled and technical men waiting outside your gate wanting to go to work at any pay scale.

Senator MALONE. Let me ask you about the matter of the draft and availability for military service.

Is there any exception made for badly needed technicians, so far as the draft is concerned?

Mr. LLOYD. As far as the Department of the Interior is concerned, there has been a policy set up of not asking for deferments.

However, offhand, I can't remember of a qualified technical man whom we have lost. In other words, there is more or less of a gentlemen's agreement with the various draft boards that they will not draft badly needed technical men.

Sometimes, of course, that does influence young men who would otherwise go to work elsewhere. They think they might just as well go into the military, and as they say, get their hitch over with.

Senator MALONE. Anyway, you are short of technical research men?

Mr. LLOYD. Very short of technical research men.

Senator MALONE. When you say you are short, give the committee some idea of the number of men in each particular phase of the work.

Mr. LLOYD. Well, right at the present time, without looking at the list that we have——

Senator MALONE. Just approximately.

DOZEN TECHNICAL VACANCIES

Mr. LLOYD. We have vacancies for about 12 technical men already set up, and we would set up more vacancies if we thought we could get the men. These are mostly chemists and chemical engineers for analytical work, and mostly specialized analytical work, and for various phases of titanium research.

Senator MALONE. Where would the salaries range, in your opinion, to make these men available on a competitive basis?

Mr. LLOYD. That question is a little hard for me to answer.

However, we have various categories open, and I believe generally we are $1,000 to $1,200 a year under the accepted commercial standard. That is my own opinion from our efforts to recruit.

You understand, of course, also in research, and particularly in research of a very difficult metal like titanium, it is desirable to obtain the highest caliber of men you possibly can. In fact, for some of these jobs there is no particular point in getting a man unless he is high caliber.

Senator MALONE. The results are not obtained unless they are very accurate.

Mr. LLOYD. That is right. You can fill the jobs and have that many more men on the Government payroll, but to get the results it takes men of definite qualifications, which is a more difficult proposition than just recruiting technical men of any kind.

Mr. MASTIN. Senator Malone, half the men we have now are here because of reasons of health, either for themselves or for their families. If it weren't for that thing, I wouldn't have enough men to operate the plant.

Senator MALONE. That is very interesting information. Salary doesn't attract.

Mr. MASTIN. Well, they left jobs that paid $2,000 to $5,000 a year more than they are now getting in order to come here and live in this climate.

Of course, they like the work. It is a very interesting job, but they have to come here because of health reasons.

Senator MALONE. They just had to find a climate such as we have here?

Mr. MASTIN. My two best men are in that category.

Senator MALONE. That is very interesting.

Of course, we have another argument here as to how many people would come in if they had water enough to irrigate a little land.

You are in the business of research, and the country ought to be, and certainly those of us in the Senate and Congress who know about it are very appreciative of the work you are doing. The Bureau, even 20 or 25 years ago—or at its earliest inception in the Reno area—accompiished a lot of good work.

I think you heard me mention the electrolytic manganese process, which while it has never attracted very much attention, is being used in certain parts of the work and could under certain conditions become very valuable to the country.

Your work has been very valuable in titanium and in other fields.

Now, what could you tell the committee about the possibility of improving the Kroll process, and also the possibility of other processes and their status? Tell us about processes that might be better than the Kroll process.

Mr. LLOYD. Well, that is somewhat a big order, Senator Malone.

Senator MALONE. I know it is, but we have a big order.

Mr. LLOYD. However, we are working along two principal lines at the present time.

We are trying to improve the Kroll process; as it is known, and that is, of course, the reason we like to continue operating the pilot plant at some constant production rate, since a lot of these problems can only be worked out on a continuous production rate.

We are not doing any work at the present time on what you might say is a conventional continuous Kroll process. We are doing work on modifications of the Kroll process to try to get continuous reactors, and we are also doing electrolytic work.

There have been an awful lot of comments and talk and publicity on electrolytic work. We are doing research, making very good metal in the process, I don't think there is any question about that. The problems are more or less problems of the mechanics of operating cells under the rather difficult operations that are necessary to make good titanium.

Senator MALONE. Titanium sponge or metal?

Mr. LLOYD. Well, it would be sponge.

Senator MALONE. You do make sponge electrolytically?

Mr. LLOYD. Well, at least it would be a substitute for sponge. It is not quite the same, but it still has to be consolidated by some other method.

We are doing some research work, still more or less in the drawing board stage, that we hope to produce metal that isn't in sponge form.

Senator MALONE. The electrolytic method but not in the sponge form?

Mr. LLOYD. That is a modification of the Kroll process. However, it is going to be some time.

Mr. Wartman is doing the electrolytic work and I think is more up-to-date on the ramifications, but it is going to be some time before the work we are doing is ready to be commercialized. So far as we know, that is the situation with quite a few of the commercial research workers.

Senator MALONE. An electrolytic process, by Horizons, Inc., was mentioned this morning. Are you familiar at all with the work they have done?

Mr. LLOYD. We are not familiar in any detail at all with the work Horizons has done. We know in general what the work is like, but we are not familiar with the details at all.

Senator MALONE. Well, I won't ask you to comment on a method about which you are unfamiliar, but have you had any contact with the method, and if you have, what is your general reaction as to the possibilities of it?

Mr. LLOYD. As I have said, there is no question that you can make good titanium electrolytically. That is one of the reasons there has been quite a lot—in some cases premature publicity about electrolytic processes.

The question relates to the mechanical details that have been worked out, and I think it would be impossible for us to say without making a careful study of the company's proposal, which we haven't made.

Senator MALONE. Do you have the cooperation of the private producers, the Bureau of Mines in Washington and the Bureau of Mines here, the Du Pont Co. and the Titanium Corp.? Do you operate entirely separate from everyone else, or do you have some advantages of their information?

Mr. LLOYD. Of course, the work the Bureau does is available to everybody on the same basis.

Senator MALONE. Naturally; we understand that.

Mr. LLOYD. And we have obtained some cooperation from private producers. We know in general what they are doing, and in some cases we know in detail what they are doing. Of course, naturally, some of that information comes to us confidentially.

TITANIUM TETRACHLORIDE

Senator MALONE. I am not asking you what it is.

Mr. LLOYD. But at the present time we are working quite closely with Titanium Metals Corp., for instance, on titanium tetrachloride which we both recognize as somewhat of a bottleneck.

Senator MALONE. What is the process of making titanium tetrachloride? What makes it a bottleneck?

Mr. LLOYD. That is one of the things we are trying to find out. We don't know. At the present time the material is made by several different methods.

However, the most common method is to pass chlorine over hot brickettes made from rutile or titanium dioxide mixed with a carbonaceous reducing agent. Some of the difficulties are corrosion, high

temperatures of chlorine, and handling the carryover of other impurities, particularly from rutile into the finished tetrachloride, which gives you problems in purification.

Senator MALONE. Of course, there is no shortage of chlorine? You can get all you want of that? It is a question of the method and procedure of turning it into a product you can use?

Mr. LLOYD. Some of the material that is being produced comercially by Stauffer Chemical Co. is also being made from an intermediate byproduct, which takes electric furnaces and isn't something that you can increase the capacity of just overnight. There is no particular difficulty, however; no particular technical difficulty.

Senator MALONE. If they know the amount that is going to be demanded a certain time in advance there is no problem is there?

Mr. LLOYD. Well, undoubtedly the Du Pont Co. knows more about titanium tetrachloride than onyone else. They have been in the business longer and we don't have the details of their program at all, how they operate.

Senator MALONE. They are not cooperating with the Bureau?

Mr. LLOYD. Not so far as the making of titanium tetrachloride is concerned.

We might explain that the making of titanium tetrachloride by Du Pont is also tied in with the pigment business. They were in the business of making titanium tetrachloride for making pigments before they got into the titanium end. They consider it a separate part of their plant.

Senator MALONE. And that is part of their trade secrets?

Mr. LLOYD. Yes, sir. It is one of the definite bottlenecks at the present time in the cost structure, and perhaps in the expanding rate of production of metal by the Kroll process.

Senator MALONE. How serious do you consider it? Is it something you can't whip within a reasonable time?

Mr. LLOYD. No, I don't think so.

Senator MALONE. Just one more step that you will accomplish if the demand is great enough and you get the help you need?

Mr. LLOYD. That is correct. I think it is obvious now that we should have been doing more research in the Bureau than we have in the past years in titanium tetrachloride.

Senator MALONE. Well, if you are going to do this research in titanium tetrachloride, that is part of my question without myself knowing the details. You do the necessary research in titanium tetrachloride and run your pilot plant and do all the other things that are necessary?

Mr. LLOYD. It has been rather difficult to build a satisfactory research crew to handle this titanium tetrachloride. We have not shifted any of our research men from the development, that is, basic research on electrolytic processes and on continuous reactors for this purpose. Perhaps one reason for that is that the men already have several years' experience in the other line of work.

Senator MALONE. But that is where you could use the additional 12 or 15 research men?

Mr. LLOYD. That is where we need quite a few additional men, right there, and some in helping to push our electrolytic and continuous reactors.

Senator MALONE. Would you say, if you had this 12, 15, or 20 additional research men of proper caliber, you would be an additional step ahead in the production of titanium?

Mr. LLOYD. Well, it would take a year or two.

Senator MALONE. It just takes time to train the men?

Mr. LLOYD. It takes time to train them and get results.

Senator MALONE. But without them it would be additionally delayed?

Mr. LLOYD. Without them the program is delayed that much more.

Senator MALONE. Of course, private producers, especially the du Ponts, and I presume the Titanium Corp., are conducting some research along this line.

Mr. LLOYD. I am certain Du Pont is: I know that Titanium Metals Corp. is conducting research on making and purifying titanium tetrachloride; yes.

How much basic research they are doing on the utilization of different raw materials which, of course, is one problem that the Bureau has from an overall national welfare viewpoint, I don't know. I can't answer that question.

Senator MALONE. If you had these additional research people, you could cooperate with the Titanium Corp. in furthering the whole production program.

Mr. LLOYD. We think it would definitely further the production program.

SCRAP

Senator MALONE. Turning to the scrap, we are told that scrap is not usable at the present time. What becomes of the scrap and what investigations or research are you conducting or is anyone conducting to make this scrap available?

Mr. LLOYD. I don't believe that that is a question that I can answer too well. We know that only a limited amount of scrap is going back into the industry. We are also doing some work on electrolytic processes, which is perhaps applicable to the recovery of scrap. However, it has never been definitely applied to them yet, so we don't have the complete data, complete information.

Senator MALONE. You think some electrolytic process might be applied to scrap even though it were not applied to the original manufacture of titanium?

Mr. LLOYD. Well, I say the same type of process may be used for both, actually.

However, it doesn't mean that it is only a matter of taking the scrap over and throwing it in the furnace and melting it down like it is in the steel industry. It is a good deal more expensive than that.

I might also say from the standpoint of scrap, we have not had a close association with the scrap, but apparently one difficulty is that the titanium metal, up to the present time, has been rather variable in quality and perhaps harder than it should be.

As a result, that has made the return of scrap back to the ingots somewhat more difficult than it probably will be when the quality of metal levels out a little bit.

Senator MALONE. You heard the testimony of General Metzger this morning that he had no knowledge as to how much material was

manufactured which didn't meet the specifications because they only accepted the amount that met the specifications.

Well, this amount that meets the Government's specifications, then, according to what you just said, wouldn't apply to that particular part of the scrap, would it?

Mr. LLOYD. We might say that the Government specifications were set up from a practical standpoint and not perhaps what they would like to have. They were set up from the standpoint of what was thought could be obtained from the Kroll process.

Senator MALONE. Allowing for these imperfections?

Mr. LLOYD. Allowing for these imperfections, and undoubtedly the industry would like a somewhat better quality of sponge and certainly more uniform material than they are able to get at the present time.

Senator MALONE. Your belief is that when the Kroll process, or any other process, is perfected to the point that will be possible, that the specifications will be tightened.

Mr. LLOYD. I think that is going to be definitely true. In fact, that has already been true. Specifications have been coming down on Government contracts.

Senator MALONE. I didn't get that this morning from the general's testimony. He only outlined one table of specifications and said nothing about a tightening in the contract that has just recently been let. You think it has been tightened?

The contract has been made a part of the record, but I just have not read it.

Mr. LLOYD. I have not seen the Cramet contract, but the additional contracts which have been let to Titanium Metals Corp. and Du Pont are definitely tighter than they were to start with.

Senator MALONE. The additional contracts that have been offered?

Mr. LLOYD. Yes.

Senator MALONE. The additional contract with the Titanium Corp. has not been signed or accepted.

Mr. LLOYD. I believe even without the additional contract there has been some tightening of the specifications.

Senator MALONE. We will have the company representative here anyway for that part of it.

As far as your sponge is concerned, that is furnished to the Government in sponge form?

Mr. LLOYD. Yes; furnished in sponge form.

Senator MALONE. You make no attempt to make an ingot out of it?

Mr. LLOYD. Not at the present time. The metal we are making under the terms of the DMPA contract is being shipped to various melters under allocation.

Senator MALONE. You have already outlined the size of the contract and the amount you are making.

What is your experience in the matter of power requirements? There seems to be some difference of opinion from 16 kilowatt-hours per pound to 20 kilowatt-hours per pound in the making of the sponge at this time.

Mr. LLOYD. Well, when you start to talk about titanium, no two people are using just exactly the same process; that is one of the difficulties.

However, I think when you are talking in terms—if I get your ideas correctly—you are thinking in terms of increased expansion.

Senator MALONE. And in amount of power needed.

Mr. LLOYD. And when you think in terms of that, I think you should consider the power necessary to make the magnesium and make the chlorine, whether or not it is made by the contracting manufacturer, whether it is made somewhere else in the United States, it is still power that has——

Senator MALONE. That is about 26½ kilowatt-hours; is it?

Mr. LLOYD. No; it isn't that high. That figure of 26½ was for the ingot.

Senator MALONE. That is finished ingot?

Mr. LLOYD. Yes. It depends a little bit upon the type of operation that you are carrying out.

Senator MALONE. Explain that for the benefit of the record. It is a technical thing, and we would like to know about it.

Mr. LLOYD. It is a technical question.

For instance, du Pont—and we understand Crane also—anticipate they will utilize electrically heated reduction pots. We don't know what the power requirement on those is, but we estimated it from requirements of fuel fire pots at about 3 kilowatt-hours per pound.

That is a requirement that Titanium Metals Corp. doesn't have. On the other hand, we are also using electrically heated vacuum furnaces, which neither du Pont nor Titanium Metals Corp. are using.

Our own reason for using those is that we can get by with mild steel in the reports, and from the standpoint of conservation of national materials we don't like to have to utilize a lot of critically short metal to make stainless steel reports in order to fire with gas, which is necessary if you are firing with gas.

So that is the reason there are diffierences in the amount of power we are using.

With that amount of preface, from our estimates—and naturally, the producers know a little more about it than we do—our estimates show that it should take Titanium Metals about 14½ to 15 kilowatt-hours per pound for sponge.

Senator MALONE. We will take a short recess.

(Recess taken.)

Senator MALONE. The committee will be in order.

You may proceed with your statement.

Mr. LLOYD. If it takes 15 kilowatt-hours per pound for the basic process, the total power utilized by Titanium Metals Corp. would be about 15½ kilowatt-hours, since they also heat their chlorinators electrically, which takes a small amount of power.

At the same time, considering the power necessary to make the magnesium and chlorine, it will take du Pont about 20 kilowatt-hours under their method. So I think that is the reason for the differences.

Senator MALONE. That is very good to show the difference.

Mr. LLOYD. We are actually only utilizing about 6½ kilowatt-hours per pound. We are buying all of our magnesium and titanium tetrachloride.

Mr. MASTIN. And we expect to get that down to about 5½, which is close to the minimum.

Senator MALONE. But it is being used some place else and adds up to about the same amount?

Mr. LLOYD. When you start talking about the power, that is not a serious thing at the present time, but when you start talking in terms

of 35,000 or 100,000 tons a year, then you have got to consider the power no matter where it is utilized.

Senator MALONE. Of course, one of the purposes of the hearing is to determine the availability of the power and the raw materials which go into the product.

It has already been testified by the general that—and I would like to know if you agree—there's no question about the availability of the raw material in the Western Hemisphere and in the United States.

Do you agree with that statement?

ILMENITE BASIC

Mr. LLOYD. Well, it might take some qualification. The basic material that is necessary—that is, the ilmenite—there is plenty in the United States and in North America.

Senator MALONE. You think there is plenty of it?

Mr. LLOYD. I think there is plenty.

Senator MALONE. In the United States if properly developed.

Mr. LLOYD. So far as we know there is plenty to meet the present demand.

Actually, the statistics show that we are importing about a fourth of our ore at the present time.

Senator MALONE. You are importing it from Australia?

Mr. LLOYD. This is ilmenite, not rutile.

Senator MALONE. Yes.

Mr. LLOYD. And, of course, at the present time, one of the biggest operations utilizing ilmenite is in Canada, right on the St. Lawrence River.

Senator MALONE. And there is a large deposit there?

Mr. LLOYD. It is our understanding that there is at least 100 million tons blocked out there.

Senator MALONE. You would say that the United States and Canada alone probably could furnish all of the raw material needed for almost any comprehensive production that can be foreseen at this time.

Mr. LLOYD. I think that is correct, sir.

Senator MALONE. Go ahead, then. That is an important point.

Mr. LLOYD. We are importing, at the present time, rutile from Australia.

There is a mixture of rutile and ilmenite that du Pont is utilizing which is produced in the United States. Both of the producing companies are using rutile.

Also Stauffer Chemical Co., who produces tetrachloride, are utilizing rutile. We, along with 2 or 3 commercial compaines that we know of, are doing research on the utilization of slag made from ilmenite.

This is the slag made in Canada from ilmenite. However, I wouldn't consider the lack of research along that line to be too much of a bottleneck. In case of sufficient pressure you can always make annatase out of ilmenite by the same method used to make pigments and use this for tetrachloride.

Senator MALONE. In other words, there is no problem of conversion really if an emergency arose.

Mr. LLOYD. No problem in case of emergency. Our research on slag and research by a couple of commercial companies, of course, is aimed at more economic conversion of slag into titanium tetrachloride, but it isn't a bottleneck.

Senator MALONE. Then the availability of raw materials is not a problem in case of emergency, but what about power?

Mr. LLOYD. Well, I don't know that I am qualified to answer that question.

Senator MALONE. In this area?

Mr. LLOYD. As we all know, power is rather a difficult item anywhere in the United States at the present time.

This additional 8,000 tons I believe that the general said was already scheduled, would require somewhere around 30,000 kilowatts of installed capacity and at a very high load factor.

I don't believe I am qualified to answer whether or not that power is available.

POWER

Mr. MASTIN. I would like to comment on power, Senator, if I may.

Senator MALONE. I would like for you to comment on it. Of course, we are in this area now. Naturally, it would be difficult for anyone not familiar with the power situation throughout the United States to make a general statement, but power is a local problem. If we are going into the Tennessee area, then the power problem is in the Tennessee area. If we are going into New Jersey, where the DuPont Co. is located, then the power problem is within a reasonable distance from there, but we are now in Henderson, Nev.

I would like to have any statement you can make on the availability of power, not only for what we are trying to do now and what the contract calls for when you reach the limit of the contract, but for the additional demand for titanium, if it could be made available.

Mr. LLOYD. Well, let me say this, Senator. A figure of 100,000 tons of titanium sponge has been mentioned. It would take something of the order of 400 million kilowatt hours to make that 100,000 tons.

Senator MALONE. That would be annually?

Mr. MASTIN. That would be over any period. If you made it annually, it would take it per year, of course.

Senator MALONE. What would that be in kilowatts?

Mr. MASTIN. Around 20 kilowatt-hours per pound.

Senator MALONE. But in kilowatts of energy?

Mr. MASTIN. I would have to make a calculation before I could answer that.

Senator MALONE. It is a tremendous amount of power.

Mr. LLOYD. On the other hand, 100,000 tons of titanium is a tremendous amount of titanium.

The point I am trying to make is that you have to have power to make sponge, but the part of your cost involved in that power is a very small fraction of your total cost.

For instance, we are using at Boulder City, in August, 6.65 kilowatt-hours per pound to make sponge. We make no titanium tetrachloride, no magnesium of chlorine.

Senator MALONE. But someone does make those products and someone uses power.

Mr. MASTIN. That is right. The cost of that power per pound for sponge is 7.7 cents, so 7.7 cents out of $5 is not a very large percentage of your total cost.

Senator MALONE. That is the power cost?

Mr. MASTIN. Yes. What I am trying to get at is this. That if generating capacity, that is, falling waterpower is not available, if coal is not available, people can still build diesel plants to generate the power that they need in their own locality.

Dow Chemical, who is the principal manufacturer of magnesium in this country and would probably be the only one that would furnish to various titanium producers, they make it for about 28 cents a pound and produce it principally down along the gulf coast. They are now using natural gas and from that angle they are almost unlimited in their power capacity. They can install more capacity at reasonable notice as is needed.

They can produce all the magnesium that the titanium industry can consume at any conceivable rate. So that the power developed locally is not the absolute bottleneck. It depends on the pressure on the producer.

If the producer is willing to spend a few more cents per pound for his product, if he is paid for it in return, he can buy magnesium. He doesn't have to make magnesium at his own plant. It can be made elsewhere.

So I repeat, while power is essential, it isn't a large part of your total cost; it is a very small part.

Senator MALONE. That is the power you absolutely require if you purchase some of your materials elsewhere.

Mr. MASTIN. Yes.

Senator MALONE. I am very much interested in what you just said. The price of power is not the controlling factor in the cost of the sponge?

Mr. MASTIN. No, sir.

Senator MALONE. Would you carry that a little farther? Suppose you manufactured everything here, and you used 20 kilowatt-hours per pound. You are talking about $5 per pound on a selling price. Is the price of power controlling in that event?

Mr. MASTIN. That would cost me about 8 cents a pound of titanium, if I had to use it.

Senator MALONE. For 20 kilowatt-hours?

Mr. MASTIN. Yes, sir.

Senator MALONE. Suppose it cost you 20 cents?

Mr. MASTIN. That is still a small part of the total cost.

Senator MALONE. So what you are really talking about, if you want to round out your production you need the availability of power at some reasonable price?

Mr. MASTIN. Right.

Senator MALONE. When it is a cent a kilowatt-hour, or half a cent, or whatever you can secure it for, you want to know that you are getting either firm power or a continuous supply of power?

Mr. MASTIN. That is correct. We pay a little bit over 4 mills at Boulder City. Power can be generated with oil burning diesel engines for about 8 mills, twice as much.

It still isn't an important part of our total cost. I mean, you don't want to deliberately saddle the manufacturer with an extra cost if

you can help it, but in case of emergency those kinds of things could be done to produce large quantities of metal without too much heartbreak on anyone's part.

Senator MALONE. In the production of power, steam power or diesel power, it all depends on the price of fuel. Fuel goes up so power goes up? Is that right?

Mr. MASTIN. That is right.

Senator MALONE. And if you had hydroelectric power, whatever price you secure the hydroelectric for, the dams are already constructed and the electric generating machinery installed, so it doesn't change much over the years ahead.

Your testimony is very interesting to me, that an assurance of firm power, anything within reason, such as a half a cent or a cent, really wouldn't throw you for a loss in the production of titanium?

Mr. MASTIN. That is correct.

Senator MALONE. What you want to know is that you have the power.

Mr. MASTIN. Yes, sir.

Senator MALONE. That is very interesting to me.

Do you have anything further?

Mr. LLOYD. I might add one thing, Senator Malone, when you start talking about power. The general brought up the fact this morning that it takes about 2 years to get into production on a titanium plant.

I think you will find that the items that take the longest delivery are electric items. Therefore, it may very well be an item—that is, the power may very well be an item in getting into production within a reasonable period of time.

Senator MALONE. But it is a delay in delivering power?

Mr. LLOYD. Yes.

Senator MALONE. Do you join with Mr. Mastin that it is not the cost within 2 or 3 or 4 mills that makes the difference?

Mr. LLOYD. No. While you are talking about $5 sponge, the cost of power is a relatively minor item.

PRODUCTION COSTS

Senator MALONE. The Senators in Washington always call up someone in the Bureau of Mines when we want some technical information because we know we are going to get the best information there is, because no one can profit from any secrets.

What would you say in estimating the cost of sponge over the years ahead? I am talking now about the cost of sponge, not the profit, since the profit might vary. What is the cost of sponge that you are making at the present time, and what could it be, in your opinion if your contract were stepped up?

Suppose you were in the commercial end of the production, and were given enough of a contract so that the volume would be economical. When I say that, there is a point, of course, where the additional contract wouldn't bring the cost any lower, but approximating that point, where do you think the price of sponge might land within a reasonable time if we got into production and perfected the process?

I am not talking about a continuous process, but the one we have and are using, only perhaps resulting in a more uniform product. Will you give us any information on that you can?

Mr. LLOYD. I might tell you what we know and, also, give some estimates. They are not official estimates since you probably know the Bureau has got into trouble before from estimating the cost of doing things.

Senator MALONE. You never got into any trouble answering the question of a Senator. If you do I will take care of it.

Mr. LLOYD. We have this contract with the DMPA, and of course, the Bureau is not in any position to make a profit or stand a loss.

Senator MALONE. That is right. I am talking about costs.

Mr. LLOYD. The thing was set up on the basis of $4.50 a pound, since we said we could keep costs under that.

It was necessary with the DMPA to set up a certain amount of money. We are operating at the present time well within that $4.50. Our direct production costs are running right around $3.80 on the basis that we are running at the present time.

Senator MALONE. You are running at $3.80 a pound?

Mr. MASTIN. That was for August.

Senator MALONE. And you are making about two-thirds of a ton a month?

Mr. LLOYD. We were only making a half a ton in August. This month we will be up to two-thirds of a ton and our cost figures are not yet available. They will come down to some extent.

Senator MALONE. Suppose you were making a ton a day, what would happen to your cost of $3.80?

Mr. LLOYD. Well, they will drop some; perhaps to $3.50.

I might say on that thing, Senator Malone, that one difficulty we are up against is that about 60 percent of our total cost is the cost of the titanium tetrachloride and magnesium that we are buying. The magnesium, of course, is something that is at a well-established price, but the titanium tetrachloride is the big cost item, and I think I can give some exact figures on that if you would like it.

Senator MALONE. From whom are you purchasing it?

Mr. LLOYD. From Stauffer Chemical Co. at the present time on a bid basis.

Of course, I might say in that connection again, we could get more favorable prices for titanium tetrachloride if we were able to go out and make a contract for the next 10 years, or anything like that, which we have been unable to do.

Senator MALONE. What the committee would like to know is what the actual cost is at the present time on the pilot production, what chance there is of cheapening the final cost of that product?

Mr. LLOYD. That is the reason I brought up this titanium tetrachloride, because at the present time better than 50 percent of our present cost, of our total direct production cost, is titanium tetrachloride.

Senator MALONE. Fifty percent?

Mr. LLOYD. Yes, a little over 50 percent. We don't have any way of knowing what it is actually costing the commercial companies to produce.

I mean the companies that are producing on a continuous basis, like Du Pont or Titanium Metals Corp., for instance.

Senator MALONE. Is Titanium Metals Corp., for instance, producing its own tetrachloride?

Mr. LLOYD. Yes.

Senator MALONE. Well, you have, perhaps, some idea, knowing how it is produced. What does it cost now?

Mr. LLOYD. At the present time it costs 38½ cents.

Senator MALONE. A what?

Mr. LLOYD. Pound for titanium tetrachloride.

Senator MALONE. How many pounds are used?

Mr. LLOYD. We have used 4 pounds of titanium tetrachloride to make 1 pound of titanium. It is only a fourth titanium. The recovery of the purified material is almost 100 perment. In fact, in our plant based on the purified material, as near as we can calculate, it is 100 percent.

We have made estimates on what it should cost to make titanium tetrachloride under smooth operating conditions and compared that back to the cost of making titanium.

Senator MALONE. What do you think it ought to cost if you are in volume production in a well-run outfit?

Mr. LLOYD. We think a price of somewhere around 15 cents a pound should certainly be realized, and perhaps less.

Senator MALONE. That would make a good deal of difference in the price of a ton of sponge?

Mr. LLOYD. It makes a considerable difference.

Senator MALONE. How much difference would it make?

Mr. MASTIN. $2.20, Senator, for raw material. That includes magnesium as against 95 cents if we had 15 cent tetrachloride. In terms of tetrachloride, it is $1.88 as against $0.60 or a saving of $1.28 if we can go down to 15 cents tetrachloride.

Senator MALONE. Per pound?

Mr. MASTIN. Per pound of sponge.

Senator MALONE. That would be quite a saving.

Mr. MASTIN. It would be.

Senator MALONE. Go ahead.

Mr. MASTIN. Let me add just one remark to that. It is near enough to the end of September so that I was able yesterday to make at least a rough estimate of what my September cost would be, and I have come up with one interesting figure. My total cost, including amortization, over and above the cost of raw materials is about $1.25.

Senator MALONE. A pound?

Mr. MASTIN. A pound of sponge.

Mr. MASTIN. A pound of sponge. That includes labor, utilities, supplies and repairs, laboratory services and amortization.

Senator MALONE. Power?

Mr. MASTIN. Yes, power, fuel, water.

Senator MALONE. Tetrachloride?

Mr. MASTIN. No; everything but tetrachloride and magnesium.

Senator MALONE. $1.25 a pound?

Mr. MASTIN. Yes.

Senator MALONE. And that only leaves out two items?

Mr. MASTIN. Leaves out just tetrachloride and magnesium.

I might say those are direct production costs and don't include certain things that private companies would have to pay.

Senator MALONE. We understand that. But what we are trying to get is some idea of what the final cost would be if you are in volume production and have your process perfected.

What was the cost of your tetrachloride?

Mr. MASTIN. Fifteen cents. That would be 60 cents per pound of sponge.

Senator MALONE. How much would the magnesium cost?

Mr. MASTIN. About 34 to 35 cents.

Senator MALONE. Thirty-five cents a pound?

Mr. MASTIN. That is per pound of sponge again.

Senator MALONE. That $2.20 per pound of sponge.

Do you have any idea what saving might be made in volume from this $5 per sponge to the $15 for the rolled sheet of material?

Mr. LLOYD. We don't know exactly what goes into this cost item of making the sheet. We are not in that end of the work and we don't have any ideas.

Of course, it is obvious that quite a lot of the item that goes in there is the loss of sponge; that is, between sponge and sheet.

Senator MALONE. About 40 percent loss in scrap?

Mr. LLOYD. Yes.

Senator MALONE. At the moment.

Mr. LLOYD. In other words, if you take $5 and divide it by 60 percent, somewhere around $9 of that $15 is the cost of the sponge if you are not recovering the scrap.

Senator MALONE. If you were to recover the scrap that would be a terrific reduction.

Mr. LLOYD. That would decrease the cost considerably.

Senator MALONE. Dependent, of course, on the cost of reclaiming the scrap, which I gathered from the general, right at the moment is rather an expensive process itself.

Mr. LLOYD. So far as we know, it is going to be relatively costly to recover the scrap.

Senator MALONE. If you take enough scrap so that it is an economic process, where do you think the price might land in reclaiming the scrap?

Mr. LLOYD. I don't believe that we have any data at all that we can make an estimate on that.

As I stated before, Senator Malone, we really haven't done very much work on scrap except for the overall problem of trying to reduce the impurities and to increase the uniformity of the sponge, which is obviously one of the problems in decreasing the amount of the scrap.

Senator MALONE. Well, in considering titanium in line with the history of the production of magnesium and aluminum, have you given any thought that they might in any way parallel the history of those two products, if we perfect a continuous process and the product is uniform and the volume is an economic production unit?

Mr. LLOYD. Well, if you mean that the cost will go down with time and as volume increases and technology improves, yes.

However, there are certain basic reasons why titanium in the foreseeable future won't be anywhere near the same price as magnesium.

Senator MALONE. What is the price of magnesium now?

Mr. LLOYD. Twenty-nine and a half cents.

Senator MALONE. What is the price of aluminum?

Mr. LLOYD. I am not right sure; about 20 to 22 cents.

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Senator MALONE. I am talking now about some reasonable reduction in the foreseeable future. In your judgment, what do you think the price will be in 5 to 10 years if these processes are perfected?

Mr. LLOYD. Well, in order to answer that question, we perhaps should answer it in two ways.

One is improvement in the Kroll process, as we know it at the present time, and after all, all the present production is committed to that process. I think that certainly a selling price of $3 is not out of line.

Senator MALONE. What are you talking about now?

Mr. LLOYD. About the Kroll process.

Senator MALONE. But about what product of the Kroll process?

Mr. LLOYD. The sponge; and with a somewhat more uniform and higher purity material than we have now.

There has, of course, been considerable speculation and even publicity of various electrolytic processes that can produce considerably cheaper. We just haven't got our work to the point—well, in other words, you really can't make an estimate until you can run at least some sort of a pilot-scale process, and we really haven't got out research to the point where I believe we can make any kind of a statement.

However, I might ask Mr. Wartman his opinion of the electrolytic end.

TESTIMONY OF FRANK S. WARTMAN, CHIEF, TITANIUM RESEARCH SECTION, BUREAU OF MINES, BOULDER CITY, NEV.

Senator MALONE. Mr. Wartman, I had intended to ask you a couple of questions anyway, and this is pertinent.

Do you have any definite ideas on this particular point?

Mr. WARTMAN. No. Our electrolytic process is definitely a laboratory process, and you can't base any estimates of cost at all on power.

All we can say is that we will probably be in the same range as magnesium and aluminum. That is, in the use of 10 or 15 kilowatt-hours per pound, but as far as other costs go, we can't say much.

The application of electrolysis to titanium is much more difficult than it is for magnesium or aluminum because we are working below the melting point of the metal. In magnesium or aluminum you can use terrific current densities if you wish, as long as you don't get into trouble, and no matter how fine the original droplets that are deposited they will eventually coalesce into fluid which can be removed from the cell.

In titanium, since you are working with the solid, you can't use those high current densities. At least, we have found no way to do it as yet, because if you do, the product is so fine it is useless and too unstable, so that one problem to be surmounted is that the cells are going to be larger for titanium than they are for other metals, and that is going to make more cost as far as operations go.

You also have the problem that the cells must be shielded from the atmosphere completely; in the case of sodium and magnesium and aluminum a partial shielding is quite adequate because the metal you make is adequate; it represents a loss, but it doesn't spoil what metal is left. With titanium any air leakage into the cell means that the metal is ruined so that about all we can say is that as far as we

know the power requirements would probably be the same as other active metals, but it is quite probable that the other costs will be considerably higher.

Senator MALONE. So there is no way right at the moment to adequately estimate the total cost.

Mr. WARTMAN. No.

Senator MALONE. As far as you know, is there any other method beyond the laboratory stage, and in the pilot-plant stage now?

Mr. WARTMAN. I have no knowledge of any electrolytic process that could be considered that far along.

Senator MALONE. The Horizon process was mentioned this morning. Are you familiar with that process at all?

Mr. WARTMAN. No. The Horizon process, from what I have heard, has changed several times. What they were working on has changed.

Senator MALONE. I am informed that the Horizon process has been developed by a Mr. Branch, or by the cooperation of the Union Carbide Co. Does the Union Carbide Co. cooperate with the Bureau of Mines at times?

Mr. WARTMAN. No.

Senator MALONE. So it is possible they might have such a process and we would not know about it?

Mr. WARTMAN. That is quite possible.

Senator MALONE. But your own work has not gone beyond the laboratory stage, which makes it very hard to talk about costs.

CONTINUOUS PROCESS

Mr. WARTMAN. That is right.

Senator MALONE. Mr. Wartman, while you are testifying, I would like you to tell the committee what progress you are making in perfecting a continuous process for the manufacture of titanium?

Mr. WARTMAN. Well, as far as the Kroll process goes, I have about given up hope of a continuous process.

Our work has all gone to show that it is fundamentally a batch process, in the way that the open-hearth steel process is a batch process and can be most economically handled that way.

Probably improvements in it will be more in the development of technique or larger units, and for mechanized handling to eliminate labor, as far as possible, and of course, as I have mentioned, in the reduction of costs of raw materials.

Senator MALONE. But you don't believe at this moment, at least, there is any adequate sign that you can make continuous processes applicable to the basic Kroll process.

Mr. WARTMAN. All our work goes to show that it would be very difficult, and if we did succeed, it probably wouldn't be any cheaper than the batch process.

Senator MALONE. What about a continuous process in any other method, if you have any other method you can outline for the benefit of the committee?

Mr. WARTMAN. I don't think we have gone far enough. The use of sodium offers better possibilities for a continuous process than the use of magnesium as a reducing agent, but we haven't taken it far enough to know if it will work out.

Senator MALONE. Is your work, the laboratory work, handicapped at all by the urge of the Government to actually produce titanium?

Mr. WARTMAN. No, of a very minor extent. Our handicap is principally the one that has already been mentioned, of a rather unrealistic pay scale for the younger technical men.

We have at least six authorized vacancies that we simply can't fill.

Senator MALONE. And what can you pay for your authorized vacancies?

Mr. WARTMAN. I can't give you the actual annual figure. I know we pay about $100 a month less than they can get elsewhere.

Senator MALONE. Which is enough to keep them from going to work at the Bureau.

If you could meet the scale, do you think the Bureau would be attractive enough to secure the required assistants?

Mr. WARTMAN. I think we would get our share, yes; because if the pay scale were approximately the same, I think the interest in working with a new material like titanium and the chance of getting into a new industry would help out a great deal.

Senator MALONE. Do you have hopes of a continuous process eventually being worked out which would speed up the manufacture and reduce the cost of producing titanium?

Mr. WARTMAN. Well, hopes, maybe. At present it is quite a ways in the future.

Senator MALONE. Well, we have a lot of confidence in you. You have always come up with something when you are given a little time.

Do you have any further statement?

Mr. WARTMAN. I might say one thing along that line. Naturally, we wouldn't be doing this research if we don't—rather, we wouldn't do it if we didn't think it would come out better in the end.

One reason we have liked the electrolytic approach is that the metal is more uniform; that is, it has lower impurities and is more uniform than the material by the Kroll process. That has been one continuing problem to us and to industry, the fact that the metal from the Kroll process does vary considerably.

As I say, we are carrying out along with our production, research all the time to try to produce more uniform material. It is getting better, but it still has a long way to go. That is one reason we like the looks of the electrolytic material.

Senator MALONE. When you say "a long ways," if you have the money necessary to secure the help you needed, no doubt that would speed up the work?

What do you mean by the time element then?

PROGRESS DISAPPOINTING

Mr. WARTMAN. Well, that is a little hard to give, Senator. We are quite disappointed in the progress we have made to date. I think the commercial companies are disappointed in the progress that has been made in eliminating these impurities and hardness in the variation of the metals in the Kroll process, and some of the basic reasons for the hardness and variation we do not know. Some of them we do know can be ironed out by larger operations.

Of course, obviously a larger operation, a larger reactor, is within the realm of the commercial companies, but not within the realm of

our research. So we are trying to concentrate on the purity of the ingoing materials and the things we consider that the Bureau of Mines can contribute to it.

There is a certain amount of lack of uniformity because of reaction between the titanium and the reaction vessel, both in the reduction operation and in the subsequent purification operation. Those can naturally be worked out better on a 10-ton a day scale, or something like that, than on a small scale like ours.

Some of these things we used to think were right around the corner, but now we are not so sure. In some cases it is going to be necessary to go back and perhaps study some of the basic fundamentals in more detail. Of course, when you get into fundamental research it may come out in a month or it may take 2 or 3 years to get it.

Senator MALONE. I would like to ask you, Mr. Lloyd—unless you think Mr. Wartman could better explain it—just from your standpoint, and I know of no better standpoint than the Bureau of Mines which started all of this, what do you think of the future as far as the Kroll process and the chances of working out a process better than the Kroll process, and in perfecting the process you are now working on?

Mr. LLOYD. I have already stated that as far as the Kroll process is concerned, that we feel the selling price of the metal will probably go down to $3 a pound, or somewhere in that neighborhood.

In order to get below that, we probably have got to make definite changes.

Senator MALONE. That is, an improvement of the Kroll process or a new process entirely?

Mr. LLOYD. That is the reason you have got to qualify that thing because there are certain operations in the Kroll process—take, for instance, the purification of the final sponge that we are doing. That is a high-cost process, and it is high-capital cost. We know some work that is being done in private industry to get around that process.

Senator MALONE. By the way, I was about to ask you awhile ago, do you have the full cooperation of the Titanium Corp. here?

You give them everything you get, but do they inform you when they make progress in any particular line?

Mr. LLOYD. I think it would be a little difficult to say that we get full cooperation, but we get considerable cooperation.

It should be appreciated, of course, that in addition to the Government money that is going into some of these private operations, that a good deal of private research money has gone into them also. I would say we are getting at the present time quite a lot of cooperation from Titanium Metals Corp.

Naturally, we don't know everything that is going on down there in the line of research.

Senator MALONE. There is a point that is very important. It seems a little silly to have a Government outfit working to do something that has already been done by some company within a stone's throw of the area. At the same time, in my humble opinion, we can never enter into a plan that discourages private industry in expending its own money in large amounts through lack of protection of what it discovers, because if you do, then it just will not spend it and there is no progress made at all, except your Government expenditure.

While there has been a good deal of publicity on what the Government has been doing in the last 20 years, I made an estimate that when $1 is expended by the Government, perhaps $1,000 is expended by private industry. The Government in the long run contributes not a minor amount but much less than private industry. It is only when you get into some particular problem, like you are in now, that Government work becomes very important. Like the synthetic rubber, electrolytic manganese, and now titanium.

But when these problems are national-defense problems there ought to be some way worked out for a maximum of cooperation without the loss to a private company of their own endeavors. The purpose of the question then, was to see if there was any point where the committee, or any action of Congress, could bring a greater cooperation between Government and private organizations without the loss of profit to a private outfit that spends its own money to further the work.

Do you have any further statement?

EXCHANGE OF INFORMATION

Mr. LLOYD. I might comment on that. That was the same discussion you had with the general this morning.

Senator MALONE. We are very much interested in it.

Mr. LLOYD. I don't know what mechanism can be worked out. However, it is obvious from what we know at the present time, and in considering expansion of the titanium industry, if we could get complete exchange of information between the two present commercial producers, and also others doing research in the field, I think that there is not question that the speed with which the titanium industry developed would be considerably accelerated; a pooling of ideas undoubtedly could help.

Senator MALONE. Well, we will hear from Mr. Wartman now.

Mr. WARTMAN. I don't think it is that simple. It would offer an opportunity, possibly, but whether it would be used is something else, because each company does the things they do because they think they are best.

The fact that they knew that some other company was doing it differently wouldn't necessarily mean that they would take advantage of it.

Senator MALONE. Because, to complete that statement, I can see what you mean—even if they went in with the other company and abandoned their process, they probably never could profit by it in the same manner as if they had gone ahead and perfected their own process.

Mr. WARTMAN. That is part of the basic reason.

Senator MALONE. That is simply a business proposition?

Mr. WARTMAN. Each one wants to contribute something individually so he will have same economic advantage.

Senator MALONE. Then it is only the processes that happen to be a parallel process that would fit in.

Mr. WARTMAN. That problem is a very small part. Of course, where they are doing the same thing, comparison of information would probably save a lot of wasted time.

Mr. MASTIN. I would like to go a little further on that, Senator Malone. I was talking with Mr. Vandenburg a few moments ago

about some of the several grades that we produced, and he proposed the idea that all consumers of sponge, as well as producers, sit down around a common table and hash over some of their common problems, some of the things they can talk about, not their secret material, since they can leave that out of the picture.

He thought, and I agree with him, that it would be of considerable advantage. I don't think it would be enough advantage to have meetings at monthly intervals, but we might get together once and try it experimentally and see how it worked out over a glass of beer so someone would loosen up a little bit and talk about his problems.

I believe it would be of great advantage; I mentioned to him that we had one batch of material that we were holding back and thought it wouldn't interest the millers, but he expressed considerable interest and said, "Tell us about it and we will buy it," or words to that effect.

So I believe if all members of the titanium industry could get together at least once they might find a very considerable advantage from mutual discussion.

Senator MALONE. From the general's testimony this morning, which I thought was very valuable, he seemed to be very reluctant to estimate the amount of titanium that might be manufactured within a comparatively short time if the grade could be made uniform, and if the men in charge of national defense and the men in charge of commercial plane manufacturing knew it would be available.

It seemed to land somewhere around 100,000 or 150,000 tons a year, which is a lot of titanium for 3 or 4 companies to divide up even if they pooled their process.

Of course, if one could suddenly fall into a process that cut the cost in two, they might freeze everyone else out, but the reason the committee is here now, and the reason the chairman is willing to put in all the time necessary to get the details, is because we have an idea that the lack of titanium and the lag in working out the process is delaying the manufacture of the proper material for our own national defense, which could result in an unnecessary loss of lives.

Mr. MASTIN. May I comment on that as a private citizen and not as a Bureau of Mines employee?

Senator MALONE. I would like very much for you to because we only do these things in our official position.

Mr. MASTIN. We have a great many visitors from commercial companies that come through Boulder City to look at what we are doing there.

Senator MALONE. I understand you had a Japanese visitor.

Mr. MASTIN. We had 4 of them for 3 days.

Senator MALONE. And they have every advantage of your techniques.

Mr. MASTIN. They took great advantage.

Senator MALONE. Just the same as the Titanium Corp. or the Du Pont?

Mr. MASTIN. Right; they really asked some very interesting questions, but most of these people that come here come with the idea of finding out what is involved in going into the manufacture of titanium.

Senator MALONE. In commercial quantities?

Mr. MASTIN. They want to build plants; they are nationally known concerns, or representatives of these concerns. They find it isn't too

complicated a thing. It can be done. We have done it and others can do it, so they go to Washington to talk to the DMPA, and the first question they ask is, "Have you ever run a pilot plant?" Of course, they have to say no.

So they are automatically ruled out, in my understanding. I don't know that that is the only criterion that is used, but it is one of the principal ones.

There are several nationally known firms who would go into business immediately with some Government support on the same basis that others already enjoy, if that one particular criterion was removed.

Senator MALONE. You mean they have never operated a pilot plant on titanium?

Mr. MASTIN. That is right.

Let me point out that, if that requirement is adhered to, it is going to automatically rule out most of the possible contractors with the Government, or at least delay it, because it will take a year or two to run a pilot plant long enough to comply with that requirement. That immediately moves your program that far into the future. There are any number of these firms—I would say a half or three-quarters of those that come through here are perfectly well known to be capable of undertaking a production of a new metal with available information. It isn't necessary at all, in my opinion, that they have to run a pilot plant on the production of the metal.

Senator MALONE. Well, there have been no pilot plants until very recently in this particular metal; their experience in the operation of a pilot plant would be very useful.

Mr. MASTIN. Yes, sir.

Senator MALONE. This is a particular line of endeavor.

Mr. MASTIN. But these companies that I referred to are used to taking on new lines, totally unfamiliar to their people, and making successes of them in short order.

Senator MALONE. And a lot of these people may have trained technicians, of which you have a shortage?

Mr. MASTIN. They have large staffs ready to go onto these things or who can be put onto them immediately.

Senator MALONE. Would you care to mention any of these companies?

Mr. MASTIN. I can mention some of them. For example, Eagle Picher is one, a large zinc producer; not only that, they are in lead and silver metals, and the only producer, until recently, of germanium.

They have had ample experience along allied lines to get into these things.

Calumet & Hecla, is an old established producer of copper and copper castings and fittings, and they looked at this thing. They went to the DMPA and were told, "No, we can't do a thing for you."

Senator MALONE. Just pronounce DMPA.

Mr. MASTIN. The Defense Materials Procurement Agency.

Senator MALONE. I am still going to introduce this bill.

Mr. MASTIN. I hope you succeed.

Senator MALONE. Is there a change in the authority along this line? Have they diminished the authority of DMPA and put it someplace else?

Mr. LLOYD. I can answer that. DMPA was an independent agency, which was abolished on the 1st of July. The work is still under the

Defense Materials Procurement Agency, but it is part of the General Services Administration.

Senator MALONE. At least it is some place between the White House and the national defense organization—I think it is the ODM. What do those initials stand for?

Mr. LLOYD. Office of Defense Mobilization.

Senator MALONE. I think that is the top now, and the head of it is Dr. Flemming.

Anyway, ODM will make the decision as to what company might be allocated the contract.

Mr. MASTIN. That is right.

If we continue to insist on pilot experience on titanium, the chance of getting producers is put that far into the future.

Senator MALONE. That was very interesting testimony this morning, that we have 22,000 tons of annual production to allocate to somebody. Certainly we are not making very good progress at the present time. That is no criticism of anyone.

It is, however—and that is what makes it important for the committee to know what is going on in the field—definitely holding up the use of titanium, one of the most important metals ever to be discovered for bomber and fighter airplane production.

Mr. WARTMAN. That requirement, I think, is the result of bitter experience.

I think I mentioned, or it has been mentioned, the fundamental difficulty in making titanium is the fact that it dissolves its own oxide, that in doing so its mechanical properties are changed. If you get too much oxide it becomes completely useless and there is no way of getting the oxide out once it has been dissolved.

Senator MALONE. That is a total loss of metal.

Mr. WARTMAN. Yes. You can say that from now to the end of time, but until the man has actually bumped up against it and sweated with it, it doesn't mean anything to him.

So if you turn perfectly good cash, millions of dollars, over to a company who hasn't gone through that with at least a few keymen, it means simply they are going to be experimenting on a $10 million scale instead of $100,000 scale.

The Atomic Energy Commission had that experience before the Bureau of Mines at Albany started to make zirconium on a large scale. The Atomic Energy Commission attempted to farm it out to a private company.

Senator MALONE. I think they tried it out with two companies.

Mr. WARTMAN. And both of those companies, although well qualified with years of experience in metallurgical work—one of them at least flopped miserably, and that was the reason the Bureau of Mines had to go into zirconium production. They weren't very anxious to do it.

Senator MALONE. You had a pilot plant in Oregon, and now it is producing, I believe.

Mr. WARTMAN. It was a case of necessity, because there was no other way to get the metal.

Undoubtedly this pilot plant requirement delays things, but experience has shown that there must be some intermediate stuff there or the company will waste a lot of money learning.

Senator MALONE. There could only be this to consider—and this is very important information for the committee—apparently we are very niggardly in our appropriations for some sections of the Bureau of Mines.

You might say this titanium production is a bottleneck of efficient plane production. We think $13 million is an awful lot of money, but when we stand on the Senate floor and appropriate $20 billion for Europe, it pales into insignificance.

If you had 2 or 3 additional organizations working on the problem, somebody might stumble onto something along the way and that one improvement might be worth all the money.

Would that make any sense?

Mr. WARTMAN. Oh, yes; another view of what you put up is possibly that it would be cheaper to let these companies waste a few million dollars and get the know-how quickly, rather than to get at it so slowly. It is a matter of policy.

Senator MALONE. You are in the research business. I never was in the research business. I was an engineer who used the things you produced. But I have listened to a lot of research people and someone made a remark the other day that attracted me strangely.

Somebody asked him cold turkey under what conditions did he get his new ideas, and he said when he was thinking of something else. They made fun of it, but you and I know that we stumble into one thing at times when we are trying out another thing.

I know your Bureau of Mines discovered one of the greatest deposits of tungsten in the United States when you were drilling for an entirely different metal up in Idaho, but if you hadn't been drilling you wouldn't have found it.

I think your testimony today is very important because you are getting down to the rock where the logs are jammed. That is the thing we have to know. So when we are asked for an appropriation, we at least know what you are talking and what you want to accomplish.

I know I have found out an awful lot here today from listening to this testimony.

Do you have any further statement that you would like to make?

NEED IS NOW

Mr. LLOYD. I would like to add just a little bit to that, Senator Malone. You have got two things to consider here. One, you have got to consider, do we need this metal right now?

Senator MALONE. There is no question but what we need it now.

Mr. LLOYD. And regardless of cost, because there is no question but what you can take the batch process as it is developed in the Bureau of Mines, and make metal for around $5 a pound. You can do like they did here when they put up the basic magnesium plant, put in a multimillion dollar investment, 880 cells in a row and make the material. The other things you have to consider is that several of these other companies—and I can name some of them for the record—Kennecott, Union Carbide, Monsanto Chemical and National Research working together, and I understand Kaiser Corp. is working on new developments.

Now, some of them we know something about and some we don't know very much about.

I think that that is the thing that has been holding up the people from putting their own money into the Kroll process.

Senator MALONE. The fear of a new process coming up that would cut costs?

Mr. LLOYD. Here are at least four very well qualified companies that are in the research end of the operation. So there are four well qualified companies in the experimental end of the operation, and nobody knows what is going to come out of it.

They can take the Kroll process and put a whole row of reactors in and make titanium metal. There is no question of that. I think any reasonably good industrial company in the United States can do it.

The difficulty is the pressure sufficient to do that, or can we wait for some of these other companies to come in under the usual system of letting capital—I mean private industry—carry the ball insofar as possible.

Senator MALONE. I think that will have to develop through the hearings and there will have to be judgment exercised.

Mr. LLOYD. I don't believe it is any secret, particularly, that the contract for Cramet was held up for a long time because they didn't want to commit any more capacity to the Kroll process.

Finally, they decided if they were going to get more production they would have to commit it to the Kroll process, so they went ahead and let the Cramet contract.

That is a basic decision that has to be made, faced all the way around in national defense. Do we want to commit everything now or can we afford to wait a little in the future to get something better.

Senator MALONE. Is there a paragraph in these contracts that, if in the event of a better process or a cheaper process, the company can be compensated for the cost of the change in process?

Mr. LLOYD. There is a paragraph in the contract that if the equipment is shown to be obsolete before it is paid for, that obligation is written off.

Senator MALONE. Well, it would be obsolete if a better process came along.

Mr. LLOYD. Of course, that only relates to equipment, and you know how that is. You go over here and put in an integrated process and that includes lots of things besides equipment.

Senator MALONE. Trained men and a lot of other things.

Mr. LLOYD. Trained men. For instance, you put in a magnesium process as part of a titanium process. Well, if it is determined that it is obsolete to use magnesium, and you should use something else, just how much of that total investment can be written off is probably a question for lawyers to answer.

Senator MALONE. It is suggested that tax amortization might take part of the cost. There again, I have no fear as to what a committee recommendation might be if the Government were confronted with compensating a company for changing over to a new process that would cheapen the whole manufacture of the product.

You have made a very important contribution. Do you have anything further?

Mr. LLOYD. I might say that that provision was put in there rather than any kind of a guaranty for production, because when you start guaranteeing to buy the production at $5 a pound of any kind of tonnage of titanium, that runs into astronomical dollars. That is the reason for that provision in the contract.

Senator MALONE. Has there been any offer that you know about of any company offering to take a contract for $5 a pound or less, without any guaranty from the Government?

Mr. LLOYD. Not that I know of.

Senator MALONE. Do you have any further statement, Mr. Mastin?

Mr. MASTIN. No; thank you; that is it.

Senator MALONE. Mr. Wartman, do you have any other statement you would like to offer?

Mr. WARTMAN. No.

Senator MALONE. Well, then, we very much appreciate your appearance here. Of course, this is probably not the last we will ask to hear from you.

Mr. LLOYD. Anything we can help on, Senator Malone, we will be glad to offer our opinion.

Senator MALONE. Thank you. It is getting late, and I want to say for the benefit of the witnesses who are present that tomorrow morning we will start with the Colorado River Commission.

If there are any witnesses here who for any reason must leave early tomorrow, we will try to make a special effort to complete the testimony before noon.

Mr. Smith, will you come forward and identify yourself for the record?

TESTIMONY OF ROLLIN P. SMITH, PLANT MANAGER, TITANIUM METALS CORP. OF AMERICA, HENDERSON, NEV.

Mr. SMITH. Rollin Smith, plant manager, Titanium Metals Corp. of America, Henderson, Nev.

Senator MALONE. Mr. Smith, you have heard the testimony today about the production of titanium. You are actually producing titanium, and the committee is interested in the status of your production. That is to say, the contract you have; the status of your production in relation to the contract; when you think you can meet specifications and the amount of production; your willingness to take on any additional contracts; and the availability of the raw material that enters into the production, including power.

That is rather an involved question, if you can call it a question, but I would rather you would proceed in your own way and tell us about it.

Mr. SMITH. Well, the Titanium Metals Corp. of America has a contract from General Services to build and operate a plant capable of producing 3,600 tons of titanium sponge per year, having a certain specification.

That plant is still in construction. The first production came out in October 1951, at which time we produced about 1 ton per day. In the third quarter of this year our goal was 275 tons. Our goal for the fourth quarter is 400 tons.

Upon completion some time after that we will have a capacity of 900 tons per quarter.

Senator MALONE. Would you estimate 900 tons per quarter as starting in 1954?

Mr. SMITH. We can't make that statement at this time because we have material on order and all our designs are not complete.

Senator MALONE. What would you estimate for the first quarter in 1954?

Mr. SMITH. We haven't made any estimate of it. You can see the production is increasing, and it will be something more than 400, depending on how much new equipment is in.

Senator MALONE. When were you supposed to reach your rate of production of 3,600 tons per year?

Mr. SMITH. Well, according to the original concept, it would have been a year ago this time.

Senator MALONE. When do you think you will reach it?

Mr. SMITH. It will be sometime next year.

Senator MALONE. Perhaps the latter part of the year?

Mr. SMITH. I don't think so.

Senator MALONE. You think earlier?

Mr. SMITH. It depends on things that are in motion now.

Senator MALONE. What progress are you making to improve the quality of the product; that is to say, our information is that it has been a long, hard row to meet specifications.

Mr. SMITH. Well, the specifications as originally set up in the letter of intent provided for a metal having a hardness up to 225 Brinell, and in order to make alloys suitable for commercial use, it is necessary to make a much tighter specification than is cited by the general.

Senator MALONE. What should the specification actually be in order to have a material that would roll evenly and work perfectly?

Mr. SMITH. Well, it cannot be stated that simply, Senator Malone, because the different commercial alloys can tolerate different hardnesses of sponge according to the requirements of the customer.

Senator MALONE. Well, approximately, an average.

Mr. SMITH. Well, depending on what alloys you have, anything below 200 Brinell, providing you have enough stuff substantially below that; everything up to 200 can be used.

Senator MALONE. Can be used in airplane production or any normal production?

Mr. SMITH. Yes.

Senator MALONE. What is your power requirement for your present production, or when you reach production of 3,600 tons per year?

Mr. SMITH. Well, as people before have pointed out, that was somewhat of an oversimplification; to do exactly what we intend to do, we will use about 13 to 15 kilowatt-hours per pound.

Senator MALONE. Including melting?

Mr. SMITH. Including melting.

Senator MALONE. Including the melting of the scrap?

Mr. SMITH. Including the melting of the prime sponge.

Senator MALONE. I meant sponge. You have a contract for 3,600 tons per year; that is at the rate of 10 tons per day.

Mr. SMITH. That is right.

Senator MALONE. What is the amount of power you need for continuous full production?

Mr. SMITH. We need about 110 million kilowatt-hours per year.

Senator MALONE. What is the load factor, power factor, expressed in kilowatts?

Mr. SMITH. Well, that takes about 15,000 kilowatts.

Senator MALONE. For your contract?

Mr. SMITH. Yes.

Senator MALONE. What is your load factor, if you know, on power?

Mr. SMITH. We estimate it will be 85 percent at full production.

Senator MALONE. You do have an application for an additional contract?

Mr. SMITH. The company itself has not made an application for a contract. The General Services initiate these contracts, and a year ago they asked us to determine, or attempt to acquire power for another 15 tons per day, or 5,400 tons per year.

As yet there has been no final contract, and since they are initiated by the General Services, the information it should come from them.

Senator MALONE. How much power would that require?

Mr. SMITH. It will take the same ratio as the 110, or take about 165 million kilowatt-hours per year.

Senator MALONE. Expressed in kilowatts, the 85-percent load factor, what would that be?

Mr. SMITH. About 22,000 or 23,000.

Senator MALONE. Well, you do have a contract for the 15,000 kilowatts, or 110 million kilowatt-hours per year?

Mr. SMITH. We have a firm contract with the Colorado River Commission for 151 million kilowatt-hours a year at 20,000 kilowatts.

Senator MALONE. Do you have a contract for the additional power necessary for the 15 tons per day?

Mr. SMITH. No, we don't. However, the State of Nevada has entered into a contract with Arizona for their winter surplus power, which, combined with our power, would make enough available for a limited time on a rather infirm basis.

Senator MALONE. What do you mean a "limited time"?

Mr. SMITH. Well, it is unknown. We had the Gibbs & Hill engineers make a survey of the feasibility of that source, and I have a copy of their report, if you would like to have it for your record.

Senator MALONE. An extra copy? We might mark it "Exhibit No. 1" in your testimony, and submit it for the record, not to go into the record, but just as an exhibit.

(Document above referred to "Power Sources of Titanium Metals Corp. of America," marked "Exhibit 1," is in the files of the committee.)

Mr. SMITH. The State of Nevada, through its Colorado River Commission, has made a better arrangement with Arizona which somewhat improves the situation and which is not considered in this study.

Senator MALONE. In general, of what does that consist?

Mr. SMITH. Well, the original arrangement which these people investigated was with the Arizona Public Service Co., and the recent arrangement is with the Arizona Power Authority, which covers a greater source of power.

Senator MALONE. Has that contract been made?

Mr. SMITH. There is a contract between the State of Nevada and the Arizona Power Authority.

Senator MALONE. And you would make your contract with the Colorado River Commission?

Mr. SMITH. That is necessarily so under our power contract.

Senator MALONE. In other words, the Colorado River Commission would have to contract with the Arizona Power in any case, whether it was surplus power or not?

Mr. SMITH. In order to take delivery over these facilities; yes.

Senator MALONE. What we are trying to do is to determine two things, Mr. Smith.

First, the status of the manufacture of titanium material, whether you think you are near enough to perfecting your methods so you will reach the production capacity necessary to fulfill your present contract; and secondly, if you can take an additional contract.

There are two necessary conditions: If you can fulfill it with the proper material and if you have the power necessary to do the job. You say you don't have the power to do the job now?

Mr. SMITH. We don't have all of it; we have some.

Senator MALONE. How much?

Mr. SMITH. We have 41 million kilowatt-hours a year over and above our requirement for 10 tons, plus access to this Arizona surplus.

Senator MALONE. When is that surplus supposed to be available? Is there a guaranty of any certain time that it will be available?

Mr. SMITH. Not as such, not by contract. It is a well-known fact, however, that the seasonable peaks of this part of Nevada and Arizona are 6 months apart.

They have to have capacity down there for irrigation during the summer months. The peak load up here is for heating in the winter months, so that from the load study of their system it is known that they have and will probably always have surplus power in the winter.

Senator MALONE. In other words, for them to install the capacity they need in the summer, a certain amount is surplus in the winter?

POWER POLICY

Mr. SMITH. That is right; and it is a question of whether our management wishes to risk its money against that type of arrangement of power, which is purely a policy matter.

Senator MALONE. What is the length of the growing season over there, to get some idea of their use of the power in irrigation?

Mr. SMITH. Their pumping season, most of it is in 5 months.

Senator MALONE. Their growing season must be about 10 months.

Mr. SMITH. They have some pumping load prior to the 5 peak months, and a little after.

Senator MALONE. Does that also apply to the short year when the reservoirs don't have the customary water?

Mr. SMITH. I haven't investigated that.

Senator MALONE. Well, their cycles—some call them cycles and some deny there are cycles in rainfall, but there have been times when reservoirs have been empty in both States, when all the water they had for a year, or for a greater part of the season was for pumping. I presume they would have the first call on the power, regardless.

Mr. SMITH. That is right; that is part of the nature of why these cannot be called firm power commitments.

Senator MALONE. Normally you would have the power, you think, or a part of it, at least, over a 6-month period. Those are normally called the winter months.

Of course, no one would admit they have 6 months winter here, or over there either.

Do you have knowledge here as to the percentage of power available at various times of the year? In other words, all of it would not be available after the first 6 months, but it would be available as they ceased their pumping. There would be a peak, and then they would start pumping again and you would have some power until they utilized all their capacity; is that right?

Mr. SMITH. That is right.

Senator MALONE. Do you have those figures?

Mr. SMITH. In Gibbs & Hills report here.

Senator MALONE. Would you turn to that particular table that would give us some idea as to how it will become available?

Mr. SMITH. Well, here is a table for power of 1955. It is not put up quite the way you suggested, but it shows that we would have to take from Arizona.

Senator MALONE. What month would you start taking it, in what amounts; does it show that?

Mr. SMITH. Yes; in January of that year it will be 33,000 plus kilowatts; February, 42,000; March, 47,000; April, 87,000.

Senator MALONE. That is in thousands?

Mr. SMITH. Thousands of kilowatts.

Senator MALONE. Available, from which you would take your kilowatt-hours as of that month?

Mr. SMITH. That is right; then no more until October.

Senator MALONE. What would you get then?

Mr. SMITH. 160,000; 74,000 in November, and 83,000 in December.

Senator MALONE. Well, can you build a plant with that setup? I understand from your testimony that if they needed any of this power, they could keep that part of it, or any part of it; do I understand correctly?

Mr. SMITH. That is right, if and when available.

Senator MALONE. But this is an estimated amount.

Mr. SMITH. That is right.

Senator MALONE. But whatever was available, it would be on this basis; or rather, an erratic basis through the winter months.

Mr. SMITH. It isn't firm, as you say. However, it would be a matter of policy to decide whether one was going to invest money on that basis or not.

Senator MALONE. What do you think?

Mr. SMITH. Because we have a block of firm power, and it is not necessary, in order to make titanium to recover all the magnesium and the bulk of the power goes into the recovery of magnesium chlorine from magnesium chloride.

Senator MALONE. So you might balance the power and thereby not lessen the production of titanium as much as is indicated by the power available here.

Mr. SMITH. That is possible; it affects the economics of it.

Senator MALONE. Have you yourself prepared any report for your own company that would show how you could balance this production and what you could do with it?

Mr. SMITH. No, not as much.

Senator MALONE. Well, you have not put that up to your company yet?

Mr. SMITH. Only qualitatively.

Senator MALONE. What do you think about it?

Mr. SMITH. Well, we haven't completed our studies, Senator Malone.

I believe it might be possible to, I mean it might be necessary to firm that power with some sort of diesel standby, as suggested by others here today, before the whole project would be feasible.

Senator MALONE. In other words, what you really have in mind is a secondary power contract with Arizona, supplemented by the firm contract that you have with the Colorado River Commission, and then the construction of diesel power which would, to a certain extent, assist in firming the Arizona power, or making it available so you could run your plant even if you lost a greater part of the Arizona power than is indicated here in the 6 months where they furnish no power at all.

Mr. SMITH. That is right.

Senator MALONE. But have you made any estimate of cost of such a plan, or the amount of power you would have to provide in your standby diesel power?

Mr. SMITH. Yes; we would have to put about 20,000 kilowatt standby in order to carry out that suggested program.

Senator MALONE. What does the installation of diesel power cost in this area? Have you made any estimates?

Mr. SMITH. It varies according to the type of plant, about $175 to $250 per kilowatt.

Senator MALONE. Can it be done that economically?

Mr. SMITH. Yes, it can.

Senator MALONE. $175 to what amount?

Mr. SMITH. $250.

Senator MALONE. And you need 20,000 kilowatts in your estimate?

Mr. SMITH. Yes.

Senator MALONE. Is that what I understand?

Mr. SMITH. That is correct.

Senator MALONE. Well, does the indecision on the part of your company as to whether this is a feasible operation have anything to do with the lack of enthusiasm shown by Washington as to your receiving another contract?

Mr. SMITH. Well, as I say, the initiative must come from General Services Administration.

Senator MALONE. Are they pressing you for the contract?

Mr. SMITH. Not to the best of my knowledge at this time.

Senator MALONE. It is now a quarter to 6 o'clock.

Off the record a moment.

(Discussion off the record.)

Senator MALONE. On the record.

We will adjourn to 9:30 tomorrow morning.

(Whereupon, at 6 p. m., an adjournment was taken until Tuesday, September 29, 1953, at 9:30 a. m.)

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STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

TUESDAY, SEPTEMBER 29, 1953

UNITED STATES SENATE, SPECIAL SUBCOMMITTEE
ON MINERALS, MATERIALS, AND FUEL ECONOMICS
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Henderson, Nev.

The Minerals, Materials, and Fuels Economic Subcommittee met, pursuant to adjournment, at 9:30 a. m., in the Colorado River Commission conference room, Henderson, Nev., Senator George W. Malone (chairman of the subcommittee) presiding.

Present: Senator George W. Malone, chairman of the subcommittee: Jerome S. Adlerman, counsel to the subcommittee; George R. Holderer, staff engineer to the subcommittee; and A. M. Smith, administrative assistant to Senator Malone.

Also present: (As heretofore noted.)

PROCEEDINGS

Senator MALONE. The subcommittee will be in order.

When we closed last night Mr. Rollin Smith, of the Titanium Corp., was testifying.

Mr. Smith, will you come forward.

FURTHER TESTIMONY OF ROLLIN SMITH, PLANT MANAGER, TITANIUM METALS CORP.

Senator MALONE. Mr. Smith, would you like to proceed with any further statement you may have?

Mr. SMITH. There was one subject that you wanted covered, and that was raw material.

Senator MALONE. That is correct.

I would like for you not only to tell us where you are now getting your raw material, and what are the prospects of getting raw material, whether it is the same type, rutile, ilmenite, or whatever it is, in the United States.

Mr. SMITH. Well, most of your raw material so far has been Australian rutile.

Senator MALONE. What do you mean, most of it? Are you getting some elsewhere?

Mr. SMITH. We have got some from our operation in Florida.

Senator MALONE. About what proportion?

Mr. SMITH. A very small proportion from Florida.

Senator MALONE. 10 percent?

Mr. SMITH. I think less than 10.

Senator MALONE. Five?

Mr. SMITH. Probably about 5 percent.

Senator MALONE. Is it the same type of rutile or does it come in a different form?

Mr. SMITH. Both, beach-sand-type rutile.

Senator MALONE. What percentage of titanium oxide does this raw material contain?

Mr. SMITH. Rutile ore generally contains 95 percent titanium oxide. It is probable that the future of the industry will be based on use of ilmenite, which is a titanate; ilmenite in general runs 45 to 60 percent titanium oxide.

Senator MALONE. Explain that a little more for the benefit of the record.

When you say 45 to 60 percent titanium oxide, do you mean the ilmenite material after it has been reduced, or as you mine it?

Mr. SMITH. Usually it has to be processed to a concentrate to get this level of titanium.

Senator MALONE. Then what you mean is that it can be commercially reduced to this 45- to 60-percent titanium oxide.

Mr. SMITH. That is right.

Senator MALONE. Could you give us some idea of the deposit you have examined?

Mr. SMITH. Ilmenite in general occurs in the massive form and in beach sand.

Senator MALONE. Do you mean in the rock?

Mr. SMITH. Yes. It occurs in association with magnetite in rock, and it occurs in beach sand.

The principal beach-sand deposits are in India and Florida.

Massive deposits in operation are in the Adirondack Mountains in New York and in northern Canada. There are some others in operation.

Senator MALONE. You mean the deposits that are now in actual operation?

Mr. SMITH. That is correct. They serve the titanium-pigment industry.

AVAILABILITY

Senator MALONE. What is your idea of the availability of additional deposits in the United States?

Mr. SMITH. Well, our company and other companies are aware of many other deposits through the continental United States and North America.

Senator MALONE. What is your idea of becoming self-sufficient in the production, if it became necessary, in the United States?

Mr. SMITH. Our company and other companies, too, have development programs aimed at the most economic way of treating ilmenite for the manufacture of an intermediate product from which we can make titanium tetrachloride for the metal industry.

Senator MALONE. Can we be made self-sufficient in the production or in the use of such material, in your opinion?

Mr. SMITH. Yes. There are a number of those processes which are known to be feasible, and in the event of an emergency, we could

actually base the present metal industry on the use of titanium oxide pigment.

Senator MALONE. Secured in this country?

Mr. SMITH. That is right; that is made in several hundred tons a day.

Senator MALONE. Are you familiar with the field of minerals generally classed as "strategic" and "critical" that titanium would be a substitute for in part or in whole?

Mr. SMITH. No; I am not. I am only familiar with its use as a structural metal and, to some extent, as an alloying agent.

Senator MALONE. You have heard the testimony of General Metzger yesterday, that it was a substitute for many of the scarce materials in part or in whole.

Mr. SMITH. Yes, sir.

Senator MALONE. We will come back to that subject with another witness.

Where are you disposing of your material now? Does all of it go to the Government?

Mr. SMITH. Very little of it goes there directly. Indirectly, almost all of it goes to the aircraft industry for military aircraft.

Senator MALONE. When you say indirectly, where does it go to start with?

Mr. SMITH. It goes to the airframe and engine manufacturer.

Senator MALONE. Directly?

Mr. SMITH. Either directly or to their subcontractors, such as forging concerns and so forth.

Senator MALONE. From your company?

Mr. SMITH. From our company, that is right.

Senator MALONE. But is that a part of your contract, that you are paying back the money borrowed in metal? That metal is a part of your production that you have already enumerated, or is that in addition?

Mr. SMITH. No; those commercial sales are not a part of—you mean are they part of repaying the loan?

Senator MALONE. Yes.

Mr. SMITH. No; they are not.

Senator MALONE. I don't have my notes right at hand, but I believe you started the first of the year with 1 ton per day, and now you are up to about 3 tons, approximately, per day.

Did I understand that that 3 tons went directly to the Government in repayment?

Mr. SMITH. No, sir; that goes into the manufacture of airplane components.

Senator MALONE. Well, we knew that, but you shipped direct to the airplane companies?

Mr. SMITH. Or their subcontractors, that is right.

Senator MALONE. Is that at the direction of the Government agency with whom you have the contract?

Mr. SMITH. Very recently titanium has come under allocation. They now direct which of those users get how much.

Senator MALONE. You mean only recently they had any titanium to allocate?

Mr. SMITH. No; there has been a steadily increasing production for several years.

Senator MALONE. But not enough so they could depend on the metal for any particular type of manufacture; is that right?

Mr. SMITH. Most of it has gone into prototype development.

Senator MALONE. Will you repeat that, please. I don't understand that.

Mr. SMITH. You say regular manufacture, but I think up to date most of it has gone into the manufacture of prototype equipment; that is my understanding.

Senator MALONE. Describe such equipment for the record.

Mr. SMITH. Well, jet engines, for instance. The jet engine company makes a design, makes 1 or 2 models, then gets a prototype order for 25 or 50 engines. It makes them, and then after a period of time, it is approved for production.

Most of the last 2 years have been consumed—most of the material has gone into the prototype.

Senator MALONE. In other words, there has not been sufficient of the material that has got out of the experimental stage until very recently?

Mr. SMITH. That is true. However, the approval of any new material in an engine takes, I think as is generally indicated, a long time between the design and the manufacture to do all the proof testing that is required.

Senator MALONE. Well, you heard the general testify that the reason they are not taking the plans off the drafting board now, and pointing toward construction is because they can't depend on getting the material.

Did you hear him testify to that statement?

Mr. SMITH. That they couldn't get enough?

Senator MALONE. They can't depend on getting enough to go into production, and that is what is holding them up.

Do you agree with that?

Mr. SMITH. That is right.

Senator MALONE. What do you consider the real bottleneck in the production? What has been your bottleneck, your difficulty?

Mr. SMITH. Well, we haven't had any real bottleneck. Our program has gone along more slowly than we would like, due to slow delivery of material and changes in design that have been found necessary.

Senator MALONE. You mean slow delivery of the rutile from Australia?

Mr. SMITH. No, equipment.

Senator MALONE. What kind of equipment?

Mr. SMITH. Chemical equipment.

Senator MALONE. Who were these orders placed with that held it up?

Mr. SMITH. Well, they were placed generally all over the United States, according to the manufacturers that we selected, or that our contractors selected.

Senator MALONE. Would you care to mention a couple of them?

Mr. SMITH. Offhand I don't think I have any specific example.

Senator MALONE. Is this a new kind of equipment that they have to design and manufacture?

Mr. SMITH. Much of it has been designed by our contractor.

Senator MALONE. To meet a certain specification?

Mr. SMITH. That is right.

Senator MALONE. And which has not heretofore been manufactured?

Mr. SMITH. Much of it is special, that is right.

Senator MALONE. And you believe that is the reason it has been held up?

Mr. SMITH. That is right; we have had to redesign a number of components a number of times.

Senator MALONE. Do you have any connection or any interchange of information with any other producer?

Mr. SMITH. No; only with the Bureau at Boulder City.

Senator MALONE. You have no interchange of information or no way of knowing of any progress that has been made by the du Pont Co., we will say?

Mr. SMITH. No; we have no information; that is, any more than what is generally available. We have no direct contact with them.

Senator MALONE. You heard the testimony of the general and others, more especially the Bureau of Mines, of the advantage in their opinion that might accrue in the speed of the progress of production, speeding up production, if there could be some kind of interchange of information.

Do you agree with that statement at all?

Mr. SMITH. Well, I think you have to agree in part with that. The more information that is exchanged, the better off you are.

On the other hand, you have the policy problem of one company exchanging information developed by them at the cost of large sums of money with someone else who has very little invested, with the net effect that it reduces the initiative toward doing fundamental development work.

In my own opinion, there is no very simple solution to that.

Senator MALONE. Of course, you heard what I had to say yesterday. I am in entire accord that money invested in research in private companies must in general be protected, or in the long run there would probably be much less money invested in original research.

At the same time, do you thing there might be an exception made when the Government is putting up the bulk of the money?

Mr. SMITH. By putting up the money, if you mean lending it, I don't think that makes much difference as to whether it is borrowed or put up from the company's own coffers because it has to be repaid and with interest.

Senator MALONE. Let me ask you another question.

You are to repay the loan in metals. Suppose you didn't make the metal, what happens to the loan?

Mr. SMITH. It will be repaid with cash or metal.

Senator MALONE. But suppose it just developed that you couldn't deliver; would you still have to repay the money, is that the way the contract reads?

Mr. SMITH. We would have to pay it with either cash or sponge, that is right.

Senator MALONE. And the contract reads that there is no escape. You are to pay the $13 million you have expended if you gave up the idea eventually of trying to make proper material; you would still have to repay it in cash?

Mr. SMITH. There are provisions whereby the facility which is mortgaged to the Government be returned to them.

Senator MALONE. And that would repay the loan?

Mr. SMITH. As I remember.

Senator MALONE. The material on which the money is invested?

Mr. SMITH. It would return the part that is covered by money borrowed from them, yes.

Senator MALONE. And that would repay the loan by just turning the equipment over to them that you have installed with their money?

Mr. SMITH. That is right.

Senator MALONE. It wouldn't be necessary for you to make it up in cash, then, if you couldn't make it up in metal?

Mr. SMITH. That is correct.

There was one point brought up yesterday along that line on this obsolescence which I would like to expand on a little bit.

Senator MALONE. Go right ahead.

Mr. SMITH. In the event of technical obsolescence of certain features of the process, the letter of intent provides that the substitute equipment can be installed with borrowed funds and the loan credited with the depreciated value of the piece declared obsolete.

In other words, there is not a complete credit, as was indicated yesterday.

Senator MALONE. What you have just said indicates to me that if you put $1 million in a piece of equipment, and either the process changed or the development changed that made that piece of equipment obsolete, that million can be written off.

Mr. SMITH. Providing you substitute something new and different to replace it.

Senator MALONE. At your own cost.

Mr. SMITH. No; well, actually yes. In other words, if the new device cost a million dollars and the old one cost a million dollars, and it had not depreciated, then you would install a new one, borrow a million dollars and be credited a million dollars. It is unlikely that would happen.

Senator MALONE. Let's get the record straight.

You spend a million dollars in good faith, and maybe in 6 months or 2 years, or before you get it installed—that often happens, that it becomes obsolete—you spend an additional million to replace it and you get credit for 2 million?

Mr. SMITH. That is right. No, you get credit for the million that was declared obsolete.

Senator MALONE. Well, you write that off, that million, but you have to repay the new million.

Mr. SMITH. You have to repay the new one.

Senator MALONE. But you don't repay the million that is obsolete?

Mr. SMITH. That is right.

Senator MALONE. That makes the record straight.

In other words, the Government takes that responsibility right out of your hands. You don't have the responsibility of taking the chance

of a new process or an improvement making equipment obsolete before you have had a chance to repay the cost.

Mr. SMITH. Subject to their approval, of course.

Senator MALONE. I have never heard of the Government being very strict in these things. Generally it ends up by giving it to the outfit anyway; that has been the history of the Government.

I believe that is all right. This is a new thing. I was interested in getting into the record that fact, because I don't believe that any company would be very much interested in new developments in the laboratory, in 5 or 6 different laboratories, probably including the Government's own laboratory, the Bureau of Mines—but someone might come up with a new, cheaper process that will make obsolete 20 percent or 30 percent or 50 percent of your equipment. I don't believe you should take that chance, but you are not taking it.

That is the point I want to make.

Mr. SMITH. That is right.

EXPORTS

Senator MALONE. In your operation, have you offered any titanium material that you manufactured to any foreign nation, offered to sell to a foreign nation?

Mr. SMITH. I think that you know that the Titanium Metals Corp. sells only fabricated metal, and those sales are handled by the sales department in New York.

To the best of my knowledge there has been some metal bought by the United Kingdom.

Senator MALONE. The metal itself, not the fabricated metal?

Mr. SMITH. That is right, some fabricated metal.

Senator MALONE. By "fabricated" you mean already manufactured into certain machinery?

Mr. SMITH. No; into a fabricated shape, such as sheet, bar, forging.

Senator MALONE. Then the United Kingdom has purchased from your company fabricated shapes from which they could manufacture whatever they needed to manufacture?

Mr. SMITH. Yes; I don't know to what extent, but I know that has happened.

Senator MALONE. You don't know how much?

Mr. SMITH. No, I don't.

Senator MALONE. Was that material that would meet the Government's specifications here, or was it material that lacked somewhat of meeting the specifications that have already been made part of the record here?

Mr. SMITH. That is our standard product.

Senator MALONE. That meets the standard specifications for material that can be rolled and used?

Mr. SMITH. That is right.

Senator MALONE. Then it would meet the Government specifications and could have been turned into the Government as a part of your contract?

Mr. SMITH. I don't think that is quite right. The Government only accepts titanium sponge as tender in repayment of our loan, not fabricated shapes.

Senator MALONE. It was sponge before it was fabricated.

Mr. SMITH. That is right.

Senator MALONE. What I am talking about, it was sponge that could have been turned over to the Government in repayment of the loan.

Mr. SMITH. It could have; that is right.

Senator MALONE. Could you get the amount that has been diverted from the Government and sold to either Great Britain or England, or any other nation, for a part of the record?

Mr. SMITH. It would take some time to get it. I can get that from New York.

Senator MALONE. That will be all right. How long do you think it might take?

Mr. SMITH. Two or three days.

Senator MALONE. Will you mail that direct to the Senate Office Building, addressed to the chairman.

That will include any sponge that would meet Government specifications that was diverted from the Government to your company, or any company, and sold to any foreign country. That will also include in that any sponge that was diverted to private use and not used to repay the loan, even if it were used in this country.

Does your contract have a provision that you can divert any of this material any way you wish? (See p. 106.)

Mr. SMITH. Our contract provides that the Government has a claim on the first 100 tons per quarter, which is not very much.

It then provides that the next quantities be offered to industry.

Senator MALONE. Regardless of where it is to be sold, either a foreign nation or in this country?

Mr. SMITH. I don't think the subject of what country it is sold to is mentioned in the contract.

Senator MALONE. How much are you manufacturing in this last quarter?

Mr. SMITH. 275 tons the third quarter.

Senator MALONE. And according to your contract you could send 100 tons to the Government and divert 175 tons for any purpose that you wanted to, for private industry or any nation in the world?

Mr. SMITH. That is correct.

Senator MALONE. Are you doing that?

Mr. SMITH. Presently all sales of titanium is under allocation.

Senator MALONE. Whose allocation?

Mr. SMITH. I believe ultimately the Air Force, but I am not sure.

Senator MALONE. Do you get your directions here?

Mr. SMITH. No; they come into our sales department in New York.

Senator MALONE. Who is the head of your sales department?

Mr. SMITH. Mr. T. W. Lippert.

Senator MALONE. Do you know his first name?

Mr. SMTH. Thomas, 60 East 42d Street.

Senator MALONE. That is a very interesting development. It is new to the chairman, and I think it will be new to the committee, and it may be a good idea.

However, you heard the testimony of the general yesterday, undoubtedly, that the Air Force is crying for it and don't have the assurances they need to take the plans off the drafting board and to

let contracts. The commercial companies don't dare include it for the very simple reason they are not sure they are getting to get it. Maybe they never will get it, if that is the way the contract reads.

Mr. SMITH. I think this is the best way of them getting it.

Actually in these early years of development ad use development, it is almost impossible for the order pattern to match exactly the production.

Senator MALONE. Right at the moment you just don't have any production, practically, in comparison to the need. You heard that testimony yesterday; did you not?

Mr. SMITH. Yes. Well, that is that we don't have the production now to meet the future needs. They don't necessarily coincide, Senator.

Senator MALONE. We will take a 5-minute recess at this time.

(Recess taken.)

TITANIUM DEPOSITS

Senator MALONE. The subcommittee will be in order.

What effort is your company making now to develop local raw materials—"local" meaning the United States of America—to substitute with entirety for the Australian material?

Mr. SMITH. The National Lead Co., mining provision, which handles that matter for us, as a matter of long policy, always kept up to date a complete review of all known titanium deposits on the North American Continent and abroad. That is a dynamic program in which small prospects brought to light are reviewed, cataloged.

Senator MALONE. Much of this material—and I ask it in this form because even in the location of material there is some financial advantage of either your company or the Du Pont, or any individual locating the better deposits—how much material, will you give us for the record, as to the location of these deposits and their grade that you are sure the United States could be made self-sufficient in the event it became necessary, through the production of ilmenite, and as I understand it, some titanium, some rutile deposits are known in beach sand.

How much of this other material could you furnish the committee as to the number of deposits that are known and something about the grade in the United States and in North America? I won't ask for anything that would embarrass the company.

Mr. SMITH. From my own memory, very little. I should say that there is active production of ilmenite in Idaho today which is being stockpiled in connection with the monozite.

Senator MALONE. What form is this monozite in, in sand?

Mr. SMITH. It is a dredging operation, as I understand it.

Senator MALONE. These are the monozite sands that are very plentiful in India?

Mr. SMITH. That is right, and beach sands in California. Redondo Beach has been operated from time to time to produce ilmenite. There are very large deposits of another mineral of titanium in Colorado.

There are also deposits in North Carolina, Florida, New York State, Wyoming. It is rather general.

Senator MALONE. They say it is the fourth most plentiful material on the earth's surface?

Mr. SMITH. I have seen it referred to as the fourth most prevalent structural metal on the earth's surface. I believe it is only exceeded by iron, aluminum, and magnesium.

Senator MALONE. Then in view of the general's testimony yesterday that approximatey 22,000 tons per year had been approved it is probaby because the record of production has been so much under that amount. Only 13,000 of that amount has been actually let in contracts, and they need 36,000 tons per year now with what they have on the drafting board, or with what is ready to go if they had it and if they were sure they could get all they wanted of it, and if the commercial companies were assured that they could go right ahead and not be caught with plans with which they couldn't fulfill their needs; otherwise there might be a demand for 100,000 tons or more.

Do you think then, with that in view, that the United States is the place where we should sell the metal we have?

FIRST PREFERENCE

Mr. SMITH. I am sure that the United States should and does get first preference.

Senator MALONE. What preference is this that goes to England at the present time?

Mr. SMITH. I don't know.

Senator MALONE. But it does go.

Mr. SMITH. Some has gone, that is right.

Senator MALONE. This will be developed further in the hearings of the committee, but the Chairman understands that England at this time is selling engines and other material to this country containing the froper amount of titanium when our companies are having trouble.

Do you think this sale to England would have anything to do with that production?

Mr. SMITH. I am not familiar with that at all.

Senator MALONE. You are going to get, for the benefit of the committee, the amount of this material in total that has gone there, and the amount that is going now to any foreign country, including England?

Mr. SMITH. Yes.

Senator MALONE. The contract mentions $13 million, and a total of $15 million that you can secure. How much of that amount have you utilized to date?

Mr. SMITH. Approximately $13 million.

Senator MALONE. How much money has your own company put into the operation, in addition to the $13 million? (See p. 106.)

Mr. SMITH. I don't know the figure. It is very large. It is spread over the last several years, and it is a very large sum of money.

Senator MALONE. Could you get that amount for the benefit of the record, or would it be something of a secret?

Mr. SMITH. That would be a policy matter for our officers to decide.

Senator MALONE. Would you request it for the benefit of the committee and send it in with the other information?

Mr. SMITH. Yes, sir.

Senator MALONE. You say that the Government has a claim on the first 100 tons, and that is 100 tons per year?

Mr. SMITH. Per quarter. After we reach an 1,800-ton-per-year production rate, that is.

In other words, when we are at 50 percent of capacity, at that time they have a claim on the first 100 tons per quarter.

Senator MALONE. They have no claim now?

Mr. SMITH. No.

Senator MALONE. Are they receiving any material?

Mr. SMITH. They are not receiving any sponge; no.

Senator MALONE. Are they receiving any other kind of material?

Mr. SMITH. Through these indirect channels?

Senator MALONE. No; from your company?

Mr. SMITH. They have received some fabricated material through direct contract, such as the Army Ordnance, and so forth.

Senator MALONE. They have not received any of the sponge at all?

Mr. SMITH. No.

Senator MALONE. When do you expect to reach that 1,800-ton rate of production?

Mr. SMITH. Sometime after the end of this year.

Senator MALONE. Sometime in 1954?

Mr. SMITH. Yes.

Senator MALONE. And up until that time, would you say along toward the latter part of 1954?

Mr. SMITH. No; I would say it would be in the first half of 1954.

Senator MALONE. During the first half of 1954; if you produce 900 tons in the first half of 1954, then the first 100 tons per month——

Mr. SMITH. Per quarter.

Senator MALONE. You will be forced to ship to the Government?

Mr. SMITH. At their direction if they request it.

Senator MALONE. But now there is nothing due to the Government even if they requested it because of the rate of production at this time.

Mr. SMITH. Not under the contract; that is right.

Senator MALONE. What I am trying to develop, if you will just tell us, you are not bound to give the Government anything to repay the loan if you don't reach the 1,800-ton production?

Mr. SMITH. That is not true. We have to repay the Government at the rate of 47 cents a pound for every pound of sponge produced, regardless of our production level, either in money or in sponge.

Senator MALONE. You are to pay 47 cents, but you receive $5 per pound. You repay the Government 47 cents in cash now? Have you been doing that?

Mr. SMITH. Yes; every pound produced.

Senator MALONE. And they pay you $5?

Mr. SMITH. If we tender sponge it is tendered at the rate of $5 per pound against this 47 cents per pound payment.

Senator MALONE. But you can give them 47 cents and keep all the sponge until you reach the 1,800 tons per year capacity?

Mr. SMITH. That is right.

Senator MALONE. And then dispose of it wherever you care to?

Mr. SMITH. That is right. That, I believe, is the purpose of the contract.

Senator MALONE. I don't know what the purpose of the contract is. They say they need it for airplanes and can't get it.

Do you have any further statement to make on the general program progress of the company, or how soon you believe you will be able to

attain—well, I will put the question this way: Perhaps you never intend to give them more than the first 100 tons, no matter what the production is; is that the intention of the company?

Mr. SMITH. No; at any one time, when that question comes up it will depend on the orders on the books for the material.

Senator MALONE. Whose books?

Mr. SMITH. On our books.

Senator MALONE. Suppose the orders are from your own company in the East and they are sufficient to take all the production. It will then be your own judgment as to where you ship it, would it not?

Mr. SMITH. Will you repeat that, please?

(Question read.)

Senator MALONE. Meaning the amount above the 100 tons per year that you are forced to send to the Government under your contract; anything additional you could ship wherever you please?

Mr. SMITH. Subject to the allocations, but under the contract; that is correct. That was the purpose of the contract.

Senator MALONE. I don't know what the purpose is. The purpose, according to National Defense, was to get the titanium to build airplanes.

But what I am trying to bring out here for the purposes of the record—we, of course, will call National Defense officials—but we want to find out just what kind of a contract they have and what control they have over it. I think you have made that very clear.

September 1, 1952, is the initial date that you were to reach the 3,600-ton annual production; is that correct?

Mr. SMITH. That is right.

Senator MALONE. And at the present time you are producing—well, first that would have been 10 tons per day?

Mr. SMITH. That is right.

Senator MALONE. At the present time you are producing between 3 and 4 tons per day?

Mr. SMITH. Yes; we will produce at a 400-ton rate in the fourth quarter.

Senator MALONE. And that will be 1,200 tons per year?

Mr. SMITH. Yes.

Senator MALONE. Which would be one-third of the contract.

Mr. SMITH. That will be 1,600 tons, a little more than that.

Senator MALONE. Yes, about 45 percent. This is more than 1 year beyond the date.

Mr. SMITH. That is correct.

GOVERNMENT SPECIFICATIONS

Senator MALONE. Do you have any sale for the product that you make that doesn't meet Government specifications. Have you found any sale for it?

Mr. SMITH. We make almost no material that doesn't meet the specifications, a very small fraction.

Senator MALONE. What do you do with that?

Mr. SMITH. Some of it has been sold for alloying and some of it for powder, and the rest of it is on hand.

Senator MALONE. How much do you have on hand?

Mr. SMITH. We have somewhere between 50,000 and 100,000 pounds on hand.

Senator MALONE. What do you get for it when it just lacks a little for a certain amount of reaching the Government specifications? Do you get a fair price for it?

Mr. SMITH. There isn't any definite commercial market for it.

Senator MALONE. What have you received for it, if you remember?

Mr. SMITH. I don't know; I don't have that figure.

Senator MALONE. Could you get it for the record?

Mr. SMITH. Yes, sir. (See p. 106.)

Senator MALONE. I am trying to bring out what the contract provides for.

If you produced it just a little under Government specifications and had a sale for it, you wouldn't be forced to sell any of it to the Government, would you?

Mr. SMITH. The 100 tons per quarter which they are allowed to take has to meet the specifications set forth.

Senator MALONE. It is just a fraction under, we will assume, and then you would not owe the Government anything.

Mr. SMITH. Literally that is true. Practically, though, if it were under that we wouldn't have any commercial use for it.

Senator MALONE. Well, you say you have been selling it?

Mr. SMITH. Yes; that is right; all of it.

Senator MALONE. Perhaps it could be made just a fraction under the Government specifications and be used for certain purposes; could it not?

Mr. SMITH. There would be little or no use for the material under those conditions.

Senator MALONE. What did you say you were selling it for at the present time? You were selling inferior material for certain use.

Mr. SMITH. We have sold a very small quantity for this alloying use, but it hasn't any commercial significance for this type of plant.

Senator MALONE. Well, if you will submit for the record what you get for it——

Mr. SMITH. It couldn't be done profitably.

Senator MALONE. You have testified that the bottleneck in your production has been equipment that you need that has been on order; is that the only bottleneck, or is it the principal one?

Mr. SMITH. It has been the redesign of equipment, the time taken in design plus acquiring the modifications.

Senator MALONE. The general testified yesterday that for some time the Du Pont Co. had been up to their production of 3,600 tons per year. That seemed to make it more important, if this material is as much of a necessity for airplane production and auxiliary production as the general thinks it is, to find out something about how they are doing that job.

You are aware of the fact that they are producing their entire 3,600 tons per year at that rate?

Mr. SMITH. I believe they are producing substantially less than we are.

Senator MALONE. Right at the moment?

Mr. SMITH. I think that the general testified for a much lesser amount.

Senator MALONE. I am mistaken then.

Let the record stand as to whatever it shows. I was under the impression that the testimony showed that they were up to their production. We will let that stand and find out from the company.

We were talking about power yesterday. You testified that you had some additional power that you could get as secondary power. It seemed to be second in two ways. You could get a certain amount at certain times and less if they needed the power.

Would you care to go into this power question a little further and let us know what kind of a problem you have, if any, looking forward to a future contract.

Mr. SMITH. If we are requested to expand we have enough firm Hoover Dam power under contract for another 3 or 4 tons a day, presently.

Beyond that, the only known source that has been developed is this Arizona if-and-when power which, in my personal opinion, should be firmed by some type of diesel plant or something of that nature. That is my own personal opinion.

Senator MALONE. Have you gone into the cost of what it would cost to firm the power that you outlined to the committee yesterday?

If you have it here in your report, you might outline it again for me. Could you find it in your report?

Mr. SMITH. All this that we read yesterday, that was just the requirement from Arizona during certain months of the year.

Senator MALONE. All that you could possibly get from Arizona during about a 6-month period but of varying amounts, and that would be available to you when they didn't need it; is that what you testified to?

Mr. SMITH. That is right.

Senator MALONE. Could you make an investment here for an additional tons per day, and on top of the 10 tons that you hope to reach sometime late next year, with that kind of power in mind?

Mr. SMITH. We haven't completed our engineering study of that. My personal opinion is that we would have to firm that with a captive generating plant.

Senator MALONE. Built right here?

Mr. SMITH. Built here.

Senator MALONE. Would that be diesel or natural gas, or what do you have in mind using?

Mr. SMITH. It will probably be dual fuel or dual fuel diesel, using natural gas and/or diesel oil.

Senator MALONE. What would that power cost you firmed, kilowatt-hours? Have you made any computations as to that?

Mr. SMITH. No; we haven't computed the probable net cost of the power.

Senator MALONE. What would the secondary power cost you delivered here per kilowatt-hour that you actually use?

Mr. SMITH. About 6 mills.

Senator MALONE. For secondary power that you can use 6 months per year, unless they need it, in which case they are not obligated to furnish it?

Mr. SMITH. That is right.

Senator MALONE. What do you think would be added to that cost; what would be your estimate through the construction of your plants

here to firm the power for the additional 6 months to have the capacity to take up any other month when they did not see fit to deliver it?

Mr. SMITH. What would be the effect on the power cost?

Senator MALONE. Yes; what would it add to the cost?

Mr. SMITH. Well, that would take quite a study. It would add something to it, Senator.

Senator MALONE. Two mills, three mills?

Mr. SMITH. I would hesitate to guess. The reason for that is that the generating plant could probably be operated and sell energy outside of our plant when it wasn't needed by us.

Senator MALONE. How soon could you furnish the committee with some estimate of that additional cost?

Mr. SMITH. Well, that is a rather involved study and one which we hadn't intended to make at this time, unless we have a further request.

Senator MALONE. This testimony here adds up to just one thing, and that is that they don't dare let contracts for airplanes of the design they would like to have because they can't be sure of the material.

The next quarter you are up to about 45 percent of your contract taken 3 years ago, and you say you have not applied for the additional 15 tons per day, but I understand it is pending and perhaps is being held up for some reason which I will find out—I will determine later what the reason is—but I am sure it could be nothing except the inability to fill your contract and to convince them that you have the power and the ability to do it.

You say you have no plans to determine what this power is going to cost, and maybe they have no plans to give you an additional contract. I don't know about that. We will find out about that.

It seems to me it is important to the national-defense effort to know exactly what you have in mind because you are one of two producers in the United States at the present time. Don't you think it would be important to know what you could do here?

Mr. SMITH. Yes. We have made and are making engineering studies of a preliminary nature, but not ones that would lead to the actual cost of that energy.

Senator MALONE. Is anybody making plans to determine what you would do if you were suddenly offered an additional 15-ton contract or 30-ton contract?

Mr. SMITH. Yes; we have made engineering studies of a preliminary nature along those lines.

Senator MALONE. Where would you get the power and what would you do?

Mr. SMITH. Well, on a 15-ton expansion we would probably follow the path which I have outlined here.

Senator MALONE. But you don't know what it would cost?

Mr. SMITH. Within reason we know what it would cost.

Senator MALONE. You said 6 mills for this secondary power, secondary on two counts; they could either keep it all any month they want to, or they could furnish you any part of that amount, or none of it.

Then it is secondary because it is only part of the year, and that would cost 6 mills a kilowatt-hour. If you have some reasonable idea as to what you would have to add to that cost to make your investment worth while, what is it?

Mr. SMITH. You recall we have 41 million of Hoover-Davis unused by the 10-ton operation, which would be blended with that, which would bring the cost down.

Then if you were to firm it with a diesel plant, it would be an offsetting factor, and I think it is just a guess, but I think the net cost of the energy would be about 6 mills.

Senator MALONE. What are you paying for the Hoover Dam power; that is firm power, I take it?

Mr. SMITH. Hoover-Davis together run about 3½ mills.

Senator MALONE. Then you think you could firm the power through the development of diesel power here or steam power, or any kind from fuel, and what you have left over of the Hoover Dam power and Davis that you are getting at 3½ mills, together with the 6 mills that this secondary power cost you—I understood you testified that is what that would actually cost you, 6 mills a kilowatt-hour of secondary power, did you not?

Mr. SMITH. Yes, sir.

Senator MALONE. Then something would be added to it, or do you think this additional 41 million kilowatt——

Mr. SMITH. They would tend to offset each other.

Senator MALONE. And you would have about 6 million power. Suppose you took an additional 15-ton contract? You heard the general's testimony; it is waiting for somebody.

Mr. SMITH. Without additional low-cost power in this area, I think it would pose a real problem as to where the additional 15 tons would be installed.

Senator MALONE. What would it cost you with your fuel power with no Hoover Dam; simply buying it or generating it here?

Mr. SMITH. About 1 cent.

Senator MALONE. Now we come to a question that has been posed here before, and that is the possibility of getting Shasta Dam power which would be a power available at all times, and if proper connections could be made, perhaps most nearly firm power.

Has anything been done about that proposition, or has that been dropped entirely and not considered?

Mr. SMITH. Well, the Titanium Metals Corp. hasn't done anything about it. The Colorado River Commission of Nevada negotiated.

Senator MALONE. What was the extent of their negotiations, if you know?

Mr. SMITH. I don't know specifically. I know they have a contract for 33,000 kilowatts, I believe, Shasta power.

Senator MALONE. Thirty thousand kilowatts allocated to southern Nevada. I know all about the negotiations up to that time, having been responsible for them, but I don't know what has transpired since then; do you?

Mr. SMITH. No; just what I read in the papers.

Senator MALONE. What is your impression from reading the paper?

Mr. SMITH. Well, my own impression from reading the papers is that it doesn't seem too likely that that power will be made available.

Senator MALONE. In other words, it has been written off so that the power that would be available here would be 1 cent per kilowatt-hour or more for your additional contracts, if you took any additional contracts, or if any other company came in for an additional contract; is that your belief?

Mr. SMITH. I believe that is right.

Senator MALONE. In other words, with 22,000 kilowatts, or 22,000 pounds annually already approved, with 36,000 tons requested, and according to General Metzger's testimony, 100,000 to 150,000 probably needed, we have no plans here for taking any more than 1 additional 15-ton contract.

Mr. SMITH. Unless additional low-cost power is brought in here.

Senator MALONE. I would like for the benefit of the record—and I hope that I don't seem persistent in this one particular field—if you would list for the committee the equipment that is being held up. It is possible we might help you.

Mr. SMITH. Well, all undelivered equipment as of now that is already designed is in sight, Senator; I don't think we can make use of any.

Senator MALONE. Do I understand you to say that some of the equipment is not yet designed?

Mr. SMITH. Just some refinements, that is all; minor modifications and refinements of certain parts of the plant.

Senator MALONE. Are these minor modifications and requirements, do they require the manufacture of equipment or any major change in their manufacture?

Mr. SMITH. No, not in terms of the overall project.

Senator MALONE. Is it anything that should delay an equipment company to any great extent?

Mr. SMITH. No; not beyond the normal time it takes to process that material.

Senator MALONE. I wish, in addition, you would list the equipment to which you referred having difficulty receiving, together with the companies from which it has been ordered, in addition to the other information you are going to supply us. (See p. 106.)

AIR FORCE ALLOCATION

Mr. SMITH. Yes, sir.

Senator MALONE. Did I understand you to say that the only sales you had made had been to your own company?

Mr. SMITH. This plant out here makes a titanium ingot from sponge generated here; in fact, it is the only fully integrated titanium plant. These ingots are all processed by Allegheny Ludlum, coowner of Titanium Metals Corp. of America. Fabricated material processed by Allegheny Ludlum is sold entirely by the Titanium Metals Corp. sales force.

Senator MALONE. To any customer that they may have?

Mr. SMITH. To any customer that they may have.

Senator MALONE. The Government has no call on the material at all, or no company manufacturing equipment for the Government would have any prior call on the material, under the contract?

Mr. SMITH. Under the contract; but it is now subject to allocation. The entire output of fabricated material is subject to the allocation of the Air Force.

Senator MALONE. That allocation is made by the Air Force?

Mr. SMITH. That is my understanding.

Senator MALONE. How long has that been in effect?

Mr. SMITH. One or two months, something like that.

Senator MALONE. Have they given you any orders as to where you should ship this material that is not due to the Government in repayment of the loan?

Mr. SMITH. Yes; I believe that direction is through our sales office in New York.

Senator MALONE. You don't have a copy of those instructions here, do you?

Mr. SMITH. No; we ship only ingots on order of the mills.

Senator MALONE. Would you add that to your list of material to furnish the committee, the order of allocation that you have received under the Air Force, or whoever is directing such allocation? (See p. 106.)

Mr. SMITH. Yes, sir.

Senator MALONE. It would seem to the chairman that someone is a little derelict if you are still shipping material to England and then buying engines, or whatever it is we need, from England. We are very fond of England, but it seems their priority is ahead of ours, and that would seem a little unusual.

You will get that allocation for the committee?

Mr. SMITH. Yes, sir.

UNIT POWER REQUIREMENT

Senator MALONE. Do you have any further information you think would be of interest to the committee in this connection, keeping in mind what we are trying to do is to be helpful to the Air Force, to the armed services generally, in securing the 77 minerals, materials, and fuels that is on the list of strategic and critical items.

Titanium is one of the materials, as you know. Do you have anything else you think might be helpful to the committee?

Mr. SMITH. Well, I might expand a little bit on what one or two others have said about the unit power requirement for making titanium.

Senator MALONE. Yes; I would be happy if you would do that.

Mr. SMITH. Since we have talked here generally about the Kroll method and other methods in development, however, that only concerns itself with the reduction step and purification step.

In order to make titanium you have to go several steps back of that to the processing of the ore and the clorination of the ore, purification of the chloride and the consolidation and melting of the sponge.

There are many variations, such as the one mentioned here yesterday, where you can use electric energy or fuel for heating the reactors so that the unit usage of power is very much a function of the various processes that anyone could use from beginning to end of the integrated process.

As to whether you reclaim your magnesium and chlorine from the magnesium chloride, whether you use electricity or fuel heat, what process you use for chlorination, what raw material you use, whether it is rutile, ilmenite, or slag—I think that justifies that wide dispersion of unit power requirements that have been brought up here.

Senator MALONE. Would you like to elaborate on that explanation? It is very interesting to the committee, and of course accounts for the

general difference of statements that have been made at different times.

Itemize the power requirements for each of these stages; that is, if it is done by fuel what power it would replace, if you know offhand.

Mr. SMITH. Well, all I could do would be to discuss our own, and I would prefer to do that privately, if I could.

Senator MALONE. I will withdraw the question. The answer to any question which might bring out classified material or company processes that may be secret, we will not have for the public record.

We need that material, but I wonder if you could give us any suggestion as to how we could get it for the use of the committee. We have much classified material.

Mr. SMITH. I would be pleased to give it to you privately.

Senator MALONE. Fine; if you would do that in a confidential letter, it will be treated that way. Mark the letter "Confidential."

Mr. SMITH. Yes, sir. I don't believe I have anything else.

Senator MALONE. I would like to ask you about technical help. You heard the testimony of the Bureau yesterday that they are having some difficulty because of the differential between the payment by the Government to the Bureau of Mines' technical assistants of certain grades, and private companies—presumably you and the Du Pont people—being the only ones in this particular business paying higher wages.

Do you have anything to say as to where you secure your technical assistants and whether you are having any difficulty?

Mr. SMITH. I think it would be fair to say that we pay the going salary range for technical help, and due to the interesting nature of the project and to interest in this community as a place to live, we have an advantage. We have had very little difficulty in acquiring technical help.

Senator MALONE. For the same range of help you heard described here yesterday, the Bureau pays somewhere between $3,100 for starting up to $4,000, or in that range.

How would that compare with what you pay, $4,000 a year?

Mr. SMITH. Our approximate hiring rate for grades with undergraduate degrees is $350 a month or $4,200 a year, which is about the national average.

Senator MALONE. And that is just about $1,000 more annually than the Bureau can pay here for the same type of help.

Mr. SMITH. Yes, from what we heard yesterday.

Senator MALONE. Are you getting the help from the Bureau that you naturally would expect or did expect when you moved into the area? Are they making the progress you had expected them to make, and is the material available to you?

Mr. SMITH. Yes; the material is available and the help that we get from them is very beneficial and it actually is a good reason, among others, to locate here. We are very grateful for the cooperation we get from the Bureau.

Senator MALONE. If I might point up your testimony here—correct me if I am wrong, or if there are any additions you would like to make—your testimony now is that any delay is occasioned by the lack of equipment delivery or the lack or the difficulty you are having in designing equipment for a particular purpose right at the moment;

that you do expect sometime next year to reach your contract requirements; that you are now selling practically all of your material to private sources, practically all of it to your own company, and none is going to the Government in repayment of the loan except the cash of 47 cents a pound for sponge; that you have sold a quantity of such material to England, perhaps other foreign nations, and that information will be furnished the committee; is that right?

Mr. SMITH. That sums it up very well.

Senator MALONE. Further, you believe with this secondary power you are getting from Arizona on a 6-months-per-year contract, varying each month in the amount they will deliver, if they deliver it, but that any of it can be withheld, and that power will cost about 6 mills per kilowatt-hour.

However, along with the surplus power that you have or that you could have through the use of this 41 million kilowatt-hour holdover from Hoover Dam that you are not now using, together with this secondary power; and through the construction of a plant, either diesel or fuel power to firm the power here, have enough power for the 15-ton contract that is now in negotiation between you and the Government, which would make you a total of a 25-ton-per-day production and when?

Mr. SMITH. That is right.

Senator MALONE. But any further contracts that might be offered, you have no idea where the power will come from?

Mr. SMITH. That is right.

Senator MALONE. Will you be available a little later, Mr. Smith? We might need you after we hear from some of the companies.

Mr. SMITH. Yes, sir.

Senator MALONE. We will take a short recess.

(Recess taken.)

(The following letter was later supplied for the record:)

TITANIUM METALS CORP. OF AMERICA,
Henderson, Nev., November 20, 1953.

MR. JEROME S. ADLERMAN,
Counsel, Minerals, Materials, and Fuels, Economic Subcommittee,
Committee on Interior and Insular Affairs,
United States Senate, Washington, D. C.

DEAR MR. ADLERMAN: This letter is in answer to yours of November 3, 1953, in which you request that we submit seven items.

Items 2 and 4 are being prepared by our New York office and will go forward to you from that point within a few days.

Item 1.—A report entitled "Power Sources of Titanium Metals Corp. of America" prepared by Gibbs & Hill, was submitted at the time of the hearing. Please advise if this has been misplaced or if you require additional copies.

Item 3.—Item 3 asks the amount of money put into this operation by Titanium Metals Corp. of America in addition to the funds borrowed from the Government. This now amounts to approximately $8 million.

Item 5.—Item 5 requests a list of equipment which our company is now having difficulty in obtaining. At this writing, there are no items of equipment on abnormally long delivery.

Item 6.—A photostat of DPO–1, supplement 1, ordering the allocation of titanium metal is attached.

I believe the above information, with the two exceptions noted, fully answer your inquiry.

Very truly yours,

TITANIUM METALS CORP. OF AMERICA,
R. P. SMITH, *Plant Manager.*

[DPO —, Supp. 1, July 13, 1953]

EXECUTIVE OFFICE OF THE PRESIDENT, OFFICE OF DEFENSE MOBILIZATION

DEFENSE PRODUCTION ORDER 1, SUPP. 1—SCARCE AND CRITICAL MATERIALS AUTHORIZED FOR GENERAL DISTRIBUTION IN THE CIVILIAN MARKET

Pursuant to section 101 (b) of the Defense Production Act of 1950, as amended by section 3 of the Defense Production Act Amendments of 1953, and to section 2 of Executive Order 10467, dated June 30, 1953, I have authorized the control of the general distribution in the civilian market of titanium sponge and titanium metal (ingot and mill products) and find (1) that they are scarce and critical materials essential to the national defense, and (2) that the requirements of the national defense for such materials cannot otherwise be met without creating a significant dislocation of the normal distribution of such materials in the civilian market to such a degree as to create appreciable hardship.

Titanium sponge and titanium metal (ingot and mill products) are hereby added to Schedule A of Defense Production Order 1 (18 F. R. 3805).

ARTHUR S. FLEMMING, *Director.*

TITANIUM METALS CORP. OF AMERICA,
New York 6, N. Y., November 25, 1953.

Mr. JEROME S. ADLERMAN,
Counsel, Minerals, Materials and Fuels Economic Subcommittee,
Committee on Interior and Insular Affairs,
United States Senate, Washington, D. C.

DEAR MR. ADLERMAN: In your letter of November 6, 1953, addressed to Mr. Rollin P. Smith, plant manager, Titanium Metals Corp. of America, Henderson, Nev., you asked for certain information to be supplied to the Minerals, Materials and Fuels Economic Subcommittee of the Interior and Insular Affairs Committee. In his letter of November 20, Mr. Smith gave the information for all but items 2 and 4.

Item 2 asked for the amount of sponge (or fabricated shapes) meeting Government specifications which was sold directly or indirectly to any foreign country. No sponge was sold directly or indirectly to any foreign country. Fabricated shapes as per the attached table were sold to the countries indicated in the period given. Two tons of the above amount went to C. Tennant & Sons Co. in New York, and 27 tons to United Kingdom Ministry of Supply, in care of Henry Gardner & Co., Ltd., London. All shipments were covered by appropriate export license approvals.

Item 4 asked the sales price received for sponge which did not meet Government specifications. No sponge has been sold which does not meet Government specifications.

I believe this completes the information requested in your letter of November 6, 1953.

Yours very truly,

E. R. ROWLEY, *President.*

Fabricated shapes

	Tons
1950:	
England	0.25
Canada	.33
1951:	
England	2.16
Canada	1.16
1952:	
England	.75
Canada	1.0
1953:	
England	28.0
Canada	.05
Japan	.003
Total	33.733

Senator MALONE. The committee will be in order.

We are really intending to complete our work today. We have taken a little more time than I had anticipated, but I think it has been worth it for the record.

Our next witness is Earl Richards, who is vice president of Republic Steel.

Mr. Richards, if you have anyone with you that you would like to sit with you during your testimony, just call them up to the table with you.

Mr. RICHARDS. I am all alone.

Senator MALONE. Then you may identify yourself for the record, and make any statement you care to, in your own way.

TESTIMONY OF EARL RICHARDS, VICE PRESIDENT, REPUBLIC STEEL CORP.

Mr. RICHARDS. As you said, I am vice president of Republic Steel Corp.

For a number of years I was in charge of operations of the mines, the steel plants, and the manufacturing plants.

Senator MALONE. Charles White is your president?

Mr. RICHARDS. Yes.

Senator MALONE. And to my certain knowledge, he is, in my opinion, one of the best American citizens and one of the best men in the steel business.

Mr. RICHARDS. I will have to agree to that 100 percent.

After the war we ran into the different problems that you are experiencing, and we felt the need of mine planning for the future. Since I was involved in operations the management thought I knew what the troubles were, so I was made vice president in charge of planning and development, to consider the problems like we have here today.

To understand where Republic is in this picture, I would like to state that we make about the whole range of steel compositions. Among these are alloys, including stainless. We are one of the largest producers of that kind of product.

It so happens that the rolling equipment and the melting technique, while not exactly the same as for titanium, is so closely related that we felt we were naturals to get into the titanium business from the melting standpoint and from the rolling standpoint.

But from one standpoint we didn't think we should get into it, and that is the sponge manufacture. As we understand it, that is a very involved and difficult chemical proposition. We felt we have very fine capable chemical people in the United States to do this job, and they should do what they know—that is, do the chemical part and we ought to try to confine our efforts to what we know, which is melting and rolling.

So we have progressed along that line and we have made excellent progress, I feel. Our biggest problem is sponge, lack of sponge.

Senator MALONE. You are talking about titanium sponge?

Mr. RICHARDS. Titanium sponge.

At the present time we have to limit our orders. We have to hold down our sales department because we can't get the sponge.

At the same time we have tried to follow the wishes of the Government. They said, "We need more capacity." We have gone out and increased it. I might say, our rolling equipment as it is, is pretty much usable, but for melting, we had to build new furnaces.

We have gone ahead and expanded our furnace facilities. We have a new one and that puts us in this position: right now we are idle about 50 percent of the time due to lack of sponge.

The first quarter we will be idle about 86 percent of the time due to lack of sponge. If the Government needs it, we can put in more furnaces because we have the rolling facilities, but our percentage of idleness would be still more.

Our big problem is sponge. As I said, we could have attempted to go into the sponge manufacture and be fully integrated like we are in steel. But, as I say, this being a rather involved chemical process, we thought that the country could make better progress and we would all do a better job if we would do the things for which we had experience. So we are not in the sponge business, and there is our problem.

Senator MALONE. I was going to ask at this point, how much sponge have you received over a certain period?

Mr. RICHARDS. Except for small quantities recently received from the Bureau of Mines, we are receiving sponge right now from our only source, that is du Pont, at the rate of approximately—well, this month (September) about 12½ tons of sponge for the whole month from du Pont.

The rest of the months of the year it will probably be around 15 tons a month. We will get more when their new unit goes into operation next year.

We will get 21½ tons of sponge, but we can melt 180 tons of sponge in January. Our rolling equipment is there, which is expensive, and takes a long time to build.

We have the men that have been brought up in the steel business, rolling has been their whole life, and we have those people to use, but to utilize that experience and rolling capacity we must put in the melting furnaces.

We are willing to do that with our own money, and it can be done, and we can put a new furnace in in less than 9 months. We can double, triple, or quadruple that capacity if we can get the sponge.

Senator MALONE. Let me ask you, Mr. Richards—your testimony is of great interest to the committee—what would you do with 180 tons per month if you received it and rolled it? Can you sell it? Is there a market for that much sponge?

Mr. RICHARDS. Senator Malone, here is the position we take. We have heard the same testimony that you heard from the general. I happen to be on the Titanium Melting and Fabricating Committee.

Senator MALONE. That is a Federal committee?

Mr. RICHARDS. Yes; in Washington.

Senator MALONE. What do you call it?

Mr. RICHARDS. It is the Titanium Melting and Fabricating Committee. The Government is constantly saying they need this sponge. We may not have the orders right immediately, but we feel, as the general says, the minute they feel they have the sponge they are going to put it into the designs of their planes, and we know the commercial planes can use it.

We know that in time there will be a lot of applications for it in industry. We know of applications for it right now in our own plant if we had the titanium, but of course all titanium goes to the Government.

Senator MALONE. Go ahead.

Mr. RICHARDS. So I said that we feel that we ought to have a lot of more capacity than that because the need is here.

Senator MALONE. Do you agree with the general in his testimony that that added up perhaps to 100,000 tons per year, providing all of the designers in the various fields could feel confident enough of the arrival of the metal on time to put their plans into operation?

Mr. RICHARDS. Well, Senator Malone, this is just a feel or a guess. I can't back this up with data, but I would say that that figure was arrived at, at least, 2 years ago, and I would say if you once had the experience with this titanium, I can readily see that figure of 100,000.

When industry gets the feel of this and uses it in commercial planes, it ought to be somewhat more than that.

Senator MALONE. Perhaps 150,000 or 200,000?

Mr. RICHARDS. I think so, but again I can't prove that. That is just a feeling.

Senator MALONE. Upon what do you base this belief of yours, on a belief that it is really a wonder metal and is something new, and with its lightness and strength it would revolutionize the construction field in many industries?

Mr. RICHARDS. I wouldn't say revolutionize, but when you start something new you have some immediate things before you that you think you can do. When you do that, then you begin to think of something else, and the field broadens and gets bigger.

Just take a look at the aluminum industry, as an example. Aluminum is used in lots of places where, at one time, they weren't thinking of it.

Senator MALONE. Aluminum and magnesium, as long as they cost several dollars a pound there was a limited use, but when they got down to a point where their commercial use paid off, then it was almost unlimited.

Mr. RICHARDS. That is right.

TITANIUM AS A SUBSTITUTE

Senator MALONE. I don't want to interrupt your trend of thought, but let me ask you at this point, the committee has been given to understand that this titanium is a reliable substitute, in part or in whole, for several other minerals that have been called strategic and critical because this Nation has not produced enough for our own use.

Could you give us a list of minerals that titanium would prove a substitute for?

Mr. RICHARDS. I can only mention one right now and that is the jet-engine program. I don't think this is restricted. Columbium was found to be a very important metal. I understand there is not enough known columbium in the world to meet the requirements. It has been found that titanium gives satisfactory results in place of columbium.

Senator MALONE. What are the uses of columbium, particularly if that is not restricted?

Mr. RICHARDS. It is in the jet engine parts and it imparts characteristics to steel to enable it to stand up under the high temperatures that you get in a jet engine.

Senator MALONE. In other words, this material is not only approximately twice as strong as aluminum, the lightest metal per pound, but it has other qualities, including high temperatures, the alloys particularly?

Mr. RICHARDS. That is right; it also has this—which we haven't discussed today, because it is not as much of a factor in the airplane, but it is very important in naval work—it is one of the best known materials to resist sea water and salt.

You can put samples in salt water and expose them for weeks and months and there is little effect on it. Other metals will corrode very rapidly.

Senator MALONE. There is no corrosion as far as titanium is concerned under salt water?

Mr. RICHARDS. That is right.

Senator MALONE. That would be a terrific quality.

Mr. RICHARDS. That is an entirely different characteristic, that is why I say that.

Senator MALONE. You have done considerable work along the line of the metals and materials that titanium might be substituted for, have you not?

Mr. RICHARDS. Our company?

Senator MALONE. Yes, your company; haven't you had something to do with it?

Mr. RICHARDS. Not so much directly. As I say, the chief one is columbium. If there are more, I would have to go to our metallurgist to find out for you.

Senator MALONE. Would you do that? The committee is very much interested in having a list of the minerals and materials for which titanium could substitute in part or in whole in emergencies.

I understand you presented a paper on it at Washington for the War College at one time?

Mr. RICHARDS. I have prepared papers twice, and appeared twice before the College of the Armed Forces in Washington on the steel situation.

This last one was our raw material supply. There are 16 metals that are involved. I can't list them all to you offhand here, but 16 materials that you need in the steel industry. Most of them were not wholly obtainable in the United States.

I started with iron ore, bringing out that we are facing a shortage of high-grade iron ore. Then from there I took up other metals, manganese, nickel, chromium, and so forth.

I would be glad to send you a copy of it, because it is all in there, and it is accurate, while I might, going from memory, not be as accurate as that paper would be.

Senator MALONE. There are a great number of metals for which titanium might substitute in an emergency which would make this country more self-sufficient in its production in time of war, and also for its expanding economy.

Mr. RICHARDS. Well, I wouldn't say many, but there are some. Of course, titanium will take the place of stainless steel in certain applications and stainless steel has nickel and chromium.

Nickel comes from Canada and there is a shortage. Of course chromium comes from abroad so it would save metals of that nature for those applications.

Senator MALONE. Looking ahead, when we plan far enough ahead we have never been troubled too much with nickel except at the top of the war demand, have we?

Mr. RICHARDS. Well, all through the war nickel immediately became very short, because it goes into armaments, and so forth.

During World War II we had to develop what was known as "trialloys" where we used different combinations of alloys to try to substitute what you would ordinarily get from the nickel.

Even right now, since the war, I think it has been realized a few weeks ago that it has been put on the controlled list——

Senator MALONE. Nickel is on the controlled list?

Mr. RICHARDS. Yes; I think that has just been changed, and is about to be released.

Senator MALONE. What about cobalt?

Mr. RICHARDS. There is some cobalt in this country and some abroad. You don't use much cobalt, but it is important where you do use it.

Senator MALONE. But is titanium in part a substitute for cobalt?

Mr. RICHARDS. Not to my knowledge.

Senator MALONE. I was given to understand it is. We will get that information from other sources. But you will furnish a complete list?

Mr. RICHARDS. Yes; I will get that for you.

Senator MALONE. Will you furnish the minerals, not only from your speech, but confer with your metallurgist?

Mr. RICHARDS. I will get that for you.

Senator MALONE. And mail it to the Chairman, Senate Office Building, Washington, D. C. (See p. 118.)

Of course, we have a large deposit of chromite, low grade chromite in Montana. They built a $25,000,000 mill there, but as soon as the war was over they wrecked the mill.

We have some great planners in this country.

We have many lower grade deposits in California, Oregon, and Washington from which a terrific production can be secured, but not by paying $15 a day for labor as against 40 cents a day in Africa.

Mr. RICHARDS. That is, of course, true in a number of things like manganese. You can't make steel without manganese, yet we bring in 90 percent of our manganese from abroad.

We have lots of low grade manganese in this country but we have to find out how to extract it, which the Bureau of Mines is working on. I think that program ought to get lots of support. The other thing, American low grade manganese ore can't compete with these foreign ores.

If you have one company that would use foreign manganese ores and the other company used American low grade ores, there would be an economic disadvantage to the latter. There would have to be some way to encourage the use of American manganese ores.

Senator MALONE. For 75 years—and almost for the whole 175 years that we have been a Nation—we had the gumption to protect our

own labor wage living standard through what the Constitution of the United States called a duty, or what is commonly known as tariff or import fees.

But of course, without intensive education, we have now arrived at the thought that if you can get labor at 40 cents a day in some other country to produce these materials, they ought to put them in direct competition. They have no duty, tariff, or import fee, so that they are not produced in this country, but are produced across an ocean some place. You all know this one economic world, that is going to be a very nice setup when we have it, but right at the moment we are dependent in whole or in part on foreign nations across an ocean for 77 of these materials.

Many military strategists believe that you will be unable to get any scheduled number of freight ships across either ocean after world war IV has formally been opened.

Mr. RICHARDS. Yes, sir.

Senator MALONE. So that submarines alone might whip the United States in that event, could they not?

Mr. RICHARDS. Yes. We had that experience during World War II. Our imports of foreign ore were only a few million tons in peacetime, but the submarines got nearly all of our ore carriers on the ocean and cut off most of this ore.

Senator MALONE. The chairman of this committee was special consultant to the Senate Military Affairs Committee in the second war on strategic minerals and used to sit at odd times with the War Production Board.

For the first 6 months of World War II, just for 1 example, the German submarines—compared to what Russia now has—sunk and destroyed 88 to 90 percent of the ships coming out of South Africa with chromite and manganese.

Mr. RICHARDS. Yes; that is right.

Senator MALONE. It was freely discussed and understood that unless we could whip that submarine menace in the first 6 or 8 months, which we finally did, we could lose World War II, and the folks just wouldn't have known why we lost it.

Mr. RICHARDS. That is right.

Senator MALONE. We are in that condition now, aren't we?

Mr. RICHARDS. Very much so.

Senator MALONE. Or even worse?

DEPENDING ON FOREIGN SOURCES

Mr. RICHARDS. The thing that always impressed me, Senator, I remember in my school days I was taught about the great inexhaustible resources of our country and how we were perfectly self-contained. As things have gone on, for one reason or another, we are not using them, or they are not here, and we are depending more and more on foreign sources.

Senator MALONE. They are here, I would say to you, and the mining men understand how to get it. But when the Congress of the United States adopts the principle that puts the production of any certain material, whether it is tungsten or manganese or chromite, or any other material, in direct competition with the sweatshop labor of the world, the investments in this country are not sound.

Therefore, private money will not go into the business and the workingmen are out of jobs in this country.

In other words, you are just transferring the jobs to foreign soil, which is all right if you had perpetual peace, and the people who advocate this principle say that once you allow every nation in the world to produce what they can, to produce where they have the cheapest labor, then you will have perpetual peace.

The chairman of the committee does not happen to believe that. I believe that when we are helpless, we can be blackmailed into anything.

Mr. RICHARDS. I think that is right.

Senator MALONE. So that is the reason we are so much interested in this one particular metal. We are interested in 77 metals, materials, and fuels.

The 3 days' hearing in Seattle brought out a lot of testimony, and we intend to bring the rest of it out between now and Christmas.

Mr. RICHARDS. That will be a wonderful contribution.

Senator MALONE. Your testimony is so important and the completion of your testimony through your statement can be mailed to the chairman, because that is important also. (See p. 118.)

Will you proceed with your statement?

SUMMARY

Mr. RICHARDS. I prepared a little summary here that I can read If you want to stop me, you can.

Senator MALONE. Go right ahead.

Mr. RICHARDS. In the year 1948, the production of titanium in the United States was about 10 tons for the whole year, and that was almost entirely made at the Bureau of Mines.

At that time, one company was experimenting on making titanium, and since we had alloy experience they came to us to see whether we would work on the rolling technique, which we did. A large part of that early titanium was rolled in our company.

Two years later that arrangement went out and we decided that we had the people who had the know-how in rolling and who knew melting. We were also talked to by the Government, that it was something we should look into for national defense, so we decided to go ahead and get into the titanium business ourselves. We would do the melting and we would do the rolling, but we wouldn't make sponge, because we were not chemical people.

We thought the logical thing to do was as I have indicated. That is the basis we proceeded on.

At the present time we have one source of titanium sponge, and have only had that, and that is the Du Pont Co—except for some recent shipments from the Bureau of Mines. I believe it is something like a few tons a month. Of course, their capacity is limited.

Senator MALONE. You don't receive, or none has been offered from the Titanium Corp. for your use?

Mr. RICHARDS. No; that is true.

Senator MALONE. Do the Du Pont Cos. have substantially the same contract with the Government; that is, they can direct their production when they are under the 1,800-ton rate per year to any company they wish?

Mr. RICHARDS. I have not seen any documents. I can only tell you what I think is the case.

I believe the first unit that Du Pont put in they did so at their own expense, something like 900 tons a year. The present plant will be added to by a Government contract which will get up to 3,600 tons a year.

I don't know that they have any instructions to whom to give this sponge, but I feel sure that they are giving it to companies who are supplying it for the Armed Forces. Of course, we supply our titanium products, not by direction of the Government—they don't say to whom we should supply it—but our salespeople get the contracts and people that are satisfied with the quality, and so forth, but the Government is guiding the overall program.

Senator MALONE. None of the production from your plant that you know of is going to England or any foreign nation?

Mr. RICHARDS. No; not at all, sir.

Senator MALONE. Go ahead.

Mr. RICHARDS. I would like to add this: I believe if anything happens like that, it may be due to the fact that material isn't suitable; I don't know, however.

Senator MALONE. It seems to be suitable enough that we are buying the product from England—at least, we are informed unofficially and intend to get the evidence—we are buying the manufactured product from England, using the titanium. The Government is buying it.

Mr. RICHARDS. I see.

Senator MALONE. So that makes two trips across the ocean.

Mr. RICHARDS. I see.

I would like to discuss our melting facilities.

As our experience progressed with this product, starting with 1950, we have increased our furnaces until now we have 1 induction furnace and we have 3 arc furnaces.

As I stated, with these furnaces we expect to have a melting capacity of 150 tons a month. That is based on a 5-day week, of course. If we had to go further than that, we could do so to some extent.

In all this work there have been various improvements in melting techniques which have helped us on our production. It is developing quite interestingly. We are also working with the Batelle Memorial Institute. We have a contract with them to help us do the job better and work on different techniques.

For our processing facilities, as I mentioned before, it would take quite a lot more tonnage than we are talking about now to cause any problem on rolling facilities.

SPONGE BIG PROBLEM

As I say, the biggest problem is our sponge. I mentioned what our tonnages were and what we expect to have. I might add this, however.

In view of the very limited amount of sponge available to us from Du Pont—and by the way, Du Pont divides their sponge three ways. They give it to Remcru and to Sharon-Mallory and ourselves.

Senator MALONE. That is the product from the Du Pont Co.?

Mr. RICHARDS. Yes.

Senator MALONE. Is that your only source?

Mr. RICHARDS. That is our only source except for recent small tonnages from the Bureau of Mines.

We have gone to Washington and expressed our willingness to negotiate with some sponge producer, to say, "If you will give somebody else the sponge plant, we are willing to underwrite so much tonnage of that. We will guarantee to use that much production of your plant."

Senator MALONE. You will guarantee to buy a certain amount of production?

Mr. RICHARDS. That is right.

Senator MALONE. How high could you go now and in the foreseeable future in guaranteeing such a purchase?

Mr. RICHARDS. We possibly would be willing to guarantee 10 tons a day by the time it would be possible to build a new plant and have it in operation.

Senator MALONE. In addition to anything that is being done now?

Mr. RICHARDS. That is right, and possibly more. We are doing that based on faith, that the fact that the Armed Forces say they need it, and if they need it, certainly somebody will have to supply it.

Senator MALONE. In other words, right at the moment the door is wide open for anyone who can convince the Government, convince the Commission or the Department that they can make the sponge.

Mr. RICHARDS. That is right; that is very true, it seems to me.

Senator MALONE. Up to almost unlimited quantities, as far as we can see.

Mr. RICHARDS. That is right. It seems to me in this emergency we, of course, could go ahead and try to make the sponge. I do think that anybody who wants to work on a new process, or try a new process, ought to be encouraged, but due to this time element that we are facing, I think the important thing is to get sponge the surest way, recognizing that eventually that process may be obsolete. That is the price you pay to have titanium quickly, however.

Senator MALONE. Let me ask you, is the price now charged for titanium any drawback, or does it retard the sales up to the amount that you heard the General testify to and which you have mentioned?

Mr. RICHARDS. Well, as I say, we have to limit our orders because of sponge and it is not limited because of price. It is limited on ability to deliver and our ability to deliver depends on our ability to get sponge.

Senator MALONE. So at the moment the price has not been mentioned as a retarding element?

Mr. RICHARDS. No.

Senator MALONE. In the market?

Mr. RICHARDS. No.

Senator MALONE. They will take it if they can get it.

Mr. RICHARDS. I have heard the airplane people say that naturally they would like a lower price, but even at existing prices they can justify its use.

Senator MALONE. Do you have an idea of what percentage of this metal would go into a commercial plane if it were available for their designers so they could absolutely depend on its availability at the present time?

Mr. RICHARDS. No, I don't have that, Senator Malone. My figure wouldn't be reliable.

Senator MALONE. Go ahead, then.

Mr. RICHARDS. Well, as I say, that is the sponge situation.

There is also Japanese sponge. We have contacted Japan and have used some sponge from Japan and are trying to see if we can get any more sponge from Japan. Their output is small.

Of course, they propose to develop more and, of course, there may be a boomerang in that, as you mentioned yourself, Senator. Of course because of our need of sponge, we may encourage its development over there, which we may not like sometime in the future.

Senator MALONE. It might cut our own production at some time in the future and still not be available in wartime.

Mr. RICHARDS. That is right.

Senator MALONE. This committee, as you know, is instructed to investigate and report to the Senate the availability of these materials in wartime.

And for the expanding economy and the security of the Nation, which is a little different instruction than they have ever given any other committee.

And your testimony is right in the groove.

Mr. RICHARDS. I appreciate that.

Well, that is about the high spots, Senator. It gets back to one thing. Give us sponge and we will give you titanium.

Senator MALONE. Do you have any idea what the attitude of the Du Pont Co. would be if they were offered an additional contract, say 15 to 30 tons or more per year? Are they prepared to take such contracts?

Mr. RICHARDS. I have good reason to believe, if they would be asked to do it, they would respond.

Senator MALONE. In other words, their material is satisfactory; the material they are turning out now is satisfactory?

Mr. RICHARDS. Yes. They turn out a good quality of sponge. Deliveries are good and quality is good. We have a little trouble once in a while, but fundamentally it is good.

Senator MALONE. You have no fundamental trouble in rolling it satisfactorily?

Mr. RICHARDS. I wouldn't say there is any fundamental trouble, no. There are a lot of techniques and lots of different ways to do it. We have had to learn a lot of things. There is bound to be a better quality as you go along because you learn, I think the general indicated that.

Senator MALONE. You are handling it satisfactorily?

Mr. RICHARDS. I would say so.

Senator MALONE. What you are really saying is that you just have trouble in your business like everybody else.

Mr. RICHARDS. That is right; we always try to do a better job.

Senator MALONE. Do you have any other information?

Mr. RICHARDS. No, sir.

Senator MALONE. The committee would appreciate—knowing that you are experts in the business of taking the sponge material and turning out the shapes that are necessary for the industry—if you would, in addition to the specific information that the chairman has asked for, would give us some serious thought in the next few days—the chairman expects to be in Washington about the 5th of October—

and add anything to your testimony that you think would be of interest to the committee, knowing the objective of the committee.

Will you do that, Mr. Richards?

Mr. RICHARDS. I will be glad to do that, sir.

Senator MALONE. Discuss it with your metallurgical department, or with your president, whom I know very well.

Mr. RICHARDS. Yes.

Senator MALONE. And you may convey the information we are expecting his full cooperation.

Mr. RICHARDS. You can expect that, sir.

Senator MALONE. Thank you. You are excused.

(The following letter was later supplied for the record:)

REPUBLIC STEEL CORP.,
Cleveland 1, Ohio, October 16, 1953.

HON. GEORGE W. MALONE,
Senate Office Building, Washington, D. C.

DEAR SENATOR MALONE: During your hearings at Henderson, Nev., on September 28 and 29, 1953, you asked the writer to furnish some information. It is herewith submitted:

(1) You asked me about the use of titanium to save other scarce metals. As I recall, my reply was, "It is being used to replace columbium, and where it replaces stainless steel, it obviously replaces the nickel and chromium contained therein."

You then asked whether there were any other applications. I said I would have to obtain that information from our chief metallurgist. I herewith am quoting direct from Mr. E. C. Smith, our chief metallurgist:

"In wartime when cost is not the most important item, titanium and its alloys will replace a considerable amount of the present need for nickel, copper, and chromium.

"It will be a minor factor in supplanting the use of columbium, tungsten, and molybdenum.

"The presently known titanium alloys, in addition to pure titanium, have been worked into enough finished assemblies to make it logical to predict that our metal working industries are ready to shift many end use items at this time."

(2) You asked for a copy of my second talk before the College of the Armed Forces in Washington, D. C., on October 22, 1952, entitled, "The Raw Material Outlook of the Steel Industry, Particularly From a Defense Standpoint." A copy is herewith attached.

(3) You asked for further information or comments on the subject of titanium. Chiefly, it is this: We need more sponge.

As I stated at the hearings, Republic participated largely in the early rollings of titanium. In our decision to continue in the business, we felt we should stay in the field we know, that is, melting and rolling. While titanium is somewhat different, we felt that from our experience with steel and stainless we could learn how to adapt our knowledge to titanium. Such has proved to be the case.

On the other hand, we realize that the production of sponge is a chemical proposition. We therefore felt that its production should be left in the hands of chemical concerns.

We have followed the foregoing course and now we find ourselves with several other companies, in the position of a nonintegrated producer where we have the melting and the rolling facilities, but we do not have the sponge.

Incidentally, we now have a melting capacity equal to seven times the quantity of sponge available to us. We could increase our melting capacity considerably more and we already have the rolling capacity for that increase, but again, we do not have the sponge.

It seems to me that the job before us is to provide more sponge and to see that such sponge gets in the hands of nonintegrated producers, such as ourselves.

We further feel that for the immediate future, in order to save time, additional sponge facilities should be placed in the hands of those people who have demonstrated they can produce sponge of satisfactory quality and who have the know-how. In the meantime, others should be encouraged in their developments for the more remote future.

Very truly yours,

E. M. RICHARDS.

THE RAW-MATERIAL OUTLOOK OF THE STEEL INDUSTRY, PARTICULARLY FROM A DEFENSE STANDPOINT

(By E. M. Richards, vice president, Republic Steel Corp., Washington, D. C., October 22, 1952; speech presented before the Industrial College of the Armed Forces)

Two and one-half years ago it was my privilege to appear before this body to discuss the steel industry—its growth and problems. I always will remember that occasion because of the caliber of the audience, their interest, and their intelligent discussion. So, it is a pleasure and I consider it a real honor again to stand before the Industrial College of the Armed Forces, this time to present the raw-material outlook of the steel industry, particularly from a defense standpoint.

I look upon our discussion today as of a quite important nature; first, because you, being a carefully selected group of outstanding officers, will be expected to be in the forefront in the next emergency; and, second, because I propose to submit recommendations that should be taken seriously and acted upon promptly for the safety of our country.

The materials to be considered are ore, coke, and limestone for the blast furnaces; oil, scrap, and additives for the open hearths; and several nonferrous and ferroalloying metals used elsewhere throughout the steel industry.

First, let us look at ore. Several weeks ago the ore situation was included by the President's Materials Policy Commission in their report on the Resources for Freedom. They showed that with 130 million net tons of ore used in 1950, the consumption 25 years later, that is in 1975, should be 200 million net tons (since the steel industry uses gross tons instead of net tons for ore, these figures so converted, become approximately 116 million and 179 million gross tons, respectively).

Where will we get the ore? I ask this because right now in 1952 its procurement is quite a problem; and here we are talking of 50 percent more in 1975.

You might ask why is it a problem when iron is everywhere; it constitutes almost 5 percent of the earth's crust and 80 percent of all the metals consumed in the United States. You could continue the argument by saying that you could dig up the dirt in the street right in front of this building or out of your backyards, put it in a blast furnace and obtain iron. So where is the problem? All you would say would be true. But we would come face to face with a subject with which you all are familiar—economics. The dirt out of the street and out of your backyard would reduce the blast-furnace output to a trickle; and the cost of iron production would be astronomical.

This brings out the point that the iron we take from the earth's crust to make iron and steel economically must be concentrated by nature. In that form, it is known as iron ore. What is iron ore? Chemically pure iron ore is a combination of iron and oxygen, usually either Fe_2O_3 as hematite or Fe_3O_4 as magnetite, with iron contents of 69.94 percent and 72.36 percent, respectively. In nature these compounds are mixed with water and impurities, known as gangue—and, as such are known as iron ore.

Well, just what is the iron content of iron ore we use? It varies. Iron ore off the Mesabi Range is considered standard at 51.5 percent in its natural state. Anything much above that is considered very high grade, like 56 percent in Labrador ore, and 57 percent in Venezuelan ore to 67 percent to 70 percent, almost chemically pure, in Liberian ore. In the South, the chief ore is from the Birmingham region with an iron content of 34 percent.

To secure a comprehensive picture of the iron-ore situation and the steel industry as a whole, today and particularly 25 years hence, let us first take a look at it in retrospect.

In America, the first successful iron enterprise, now being restored, was established at Saugus, Mass., in 1646, just 26 years after the landing of the Pilgrims, and was supplied by a bog ore. Subsequently, other furnaces were constructed elsewhere as in Pennsylvania, New York, Virginia, New Jersey. Being dependent on and restricted by local ore deposits their output was small—and continued small until the time of the Civil War.

Just prior to and during the period of that war, profound changes began to appear with the first discovery of iron ore in the Lake Superior region and with certain developments which proved to be the seed of the modern steel industry. These developments were the disclosure in 1856 by Sir Henry Bessemer of his newly invented process of making steel; the development of Mushet in 1857 to

make the Bessemer steel usable by the addition of manganese, after the blow; the attempt by Siemens in 1862 to make open-hearth steel with his regenerative furnace which he had previously developed for glass melting; and the successful efforts of the Martin brothers of France in 1864 to make open-hearth steel from a scrap pig-iron mix in a Siemens-type regenerative furnace.

Since these new methods of producing steel were only in their development stage during the Civil War, that war was fought with iron rather than steel. In 1860, the iron produced in the United States was less than 1 million tons, that is, 919,770 net tons; and more surprising still, steel production amounted to only 2 percent of the iron production, that is, only 13,259 net tons. In fact, in 1863, the middle of the Civil War, the steel production was only 9,044 net tons. The insignificance of this tonnage can be realized by the statement that this entire output of the whole year of 1863 was produced in this country during World War II in less than 1 hour.

After the Civil War, however, the steel industry grew by geometrical proportions in the ratios of 1, 2, 4, 8, 16, 32, 64, 128, and so on.

Starting in 1860 with a steel production of 13,259 net tons, the steel industry in the United States grew by leaps and bounds, as shown by slide No. 1.

Year	Steel production ingots and steel for castings, net tons	Elapsed years to approximately double production	Year	Steel production ingots and steel for castings, net tons	Elapsed years to approximately double production
1860	13,259		1887	3,739,760	6
1868	30,000	8	1897	8,015,792	10
1870	77,000	2	1902	16,740,920	5
1872	160,108	2	1912	35,001,459	10
1875	436,575	3	1929	63,205,490	17
1878	819,814	3	1951	105,134,553	
1881	1,778,912	3			

Thus, in approximately 90 years, the increase in steel production was almost 8,000 times, and in 1953, we expect to have an ingot capacity of over 120 million net tons per year.

It is important to note that little of this would have been possible without the vast ore bodies discovered in the Lake Superior region and, incidentally, the building of the Soo locks. The ore ranges are shown on slide No. 2. Their years of discovery were as follows: Marquette in upper Michigan in 1844; Menominee in 1873 and Gogebic in 1883, both in upper Michigan and Wisconsin; Vermillion in Minnesota in 1884; and the great Mesabi of Minnesota in 1890. Note that except for Marquette, all the iron ore bodies were discovered after the Civil War and you can see how the discovery of this iron ore fitted into the economic growth of the steel industry and the movement of the steel industry westward—with the great growth being after the opening of the huge Mesabi range. All this development is shown on slide No. 3. Note that in 1890, the year the Mesabi deposits were discovered, the United States iron ore production was 16 million gross tons. See the peak during World War I, the deep sag in the depression year of 1932, and the subsequent rise to 116 million gross tons in 1951.[1]

On slide No. 4, observe how much came from the Lake Superior region, amounting to 55.8 percent in 1890, reaching approximately 85 percent in 1920, and continuing near that level to the peak of 86.2 percent in 1942, during World War II. See how this percentage has been slipping in the last 10 years—more about this later. As to the other ore bodies, these are scattered over the United States in the Adirondacks, Alabama, Utah, California, Texas, and elsewhere; and not one anywhere approaches the magnitude of the great Mesabi Range.

This brings us up to the present. Now how do we stand as to the future in iron ore reserves? According to the report of the President's Materials Policy Commission, these reserves are, as shown on slide No. 5, as follows (figures exactly as shown in report):

[1] Note, on slide No. 3, that the tonnage in 1950 is 98 million gross tons, while earlier we saw in the President's Commission's report 130 million net tons. This slide is United States ore production, while the President's Commission's report is ore consumption, including foreign ores. Further, one is gross tons and the other is net tons.

[Billion long tons]

Region	50 percent iron and over	35 to 50 percent iron	25 to 35 percent iron	Total
Lake Superior	1.6	2.5	60.0	64
Northeast			3.0	3
South		1.8	9.5	11
West	.5	.1	.2	1
Total	2	4	73	79

However, there are some very important considerations to observe from these statistics:

1. The cream of the Lake Superior regions is rapidly vanishing. Of the 79 billion tons listed above, only 1.6 billion tons, or 2 percent, is in the classification of high grade Lake Superior ore—the only kind on the northern market and known as commercial ore.

2. We will have difficulty to maintain the present production of high-grade ore in the immediate future, let alone to meet the increased needs, because of quality, and quantity remaining, as well as the physical ability to get at it.

This means we must find other sources. Where are they? The answer is in the lower-grade ores in the United States, particularly taconites, and rich foreign ores. Let us look at each:

Taconites: This is a low-grade ore of approximately 25 to 35 percent iron content abounding in the Lake Superior region. Compare this with that of 72.36 percent in pure Fe_3O_4, mentioned earlier. This difference means that approximately two-thirds of the taconite ore is impurities or gangue. However, even so, it could be used directly in the blast furnace; but we would approach a situation like unto that of making iron from the dirt in your back yard—an enormous reduction in the output of the steel industry and much increased costs. So to avoid such uneconomic procedure, we must do what is known as beneficiation of the ore at or near the mine. We must grind the ore to the fineness of talcum powder in order to separate the gangue from the iron oxide. For every 3 tons of ore ground, 2 tons of gangue must be discarded and the remaining one-third agglomerated so it can be transported in suitable shape, as pellets, for introduction into existing blast furnaces. This is essentially an extensive process for manufacturing ore.

To give you a picture of the problem and the magnitude of the taconite development, consider the Reserve Mining Co., in which Republic is a 50 percent participant, located on the eastern end of the Mesabi Range. This company plans to produce ultimately 10 million gross tons of concentrated ore, as pellets per year. It will call for a new technique to mine and beneficiate this ore, not previously known, the building of a 47-mile railroad, the building of a harbor, and the construction of 2 new towns in the Minnesota woods. This project requires an investment of over $200 million. This is American free enterprise in operation.

It will require the digging, crushing, and pulverizing of 1 ton of ore every second of the 24 hours of every day in the whole year, and the loading of a thousand cars and their transportation over 47 miles of railroad to Lake Superior and their return every day of the entire year. So you can see that this is a gigantic operation and, what is more amazing, when completed, it will provide but little more than 5 percent of the ore needs of this country.

The Reserve Mining Co., just discussed, is working only on a type of taconite known as magnetic; so are the Erie Mining Co. and the Oliver Mining Co. All three are confining their operations to approximately the eastern 35 miles of the Mesabi Range where these magnetic taconites are located. Now here is one very important point to note, namely, the taconite particles, being magnetic, can be attracted by a magnet; and this property affords a practical and efficient means of separating the ore from the gangue.

On the other hand, the vast majority of taconite, located on the other 65 miles of the Mesabi Range, as well as those in the other ranges of the Lake Superior region are nonmagnetic. This nonmagnetic taconite is a major portion of all our taconites in the Lake Superior region, and it is upon these we ultimately put much dependence. Unfortunately, no commercial process has yet been worked out to treat them and here lies an important problem for the steel industry and our country.

Any way you turn you can see what an enormous and costly problem taconite development means—whether magnetic or nonmagnetic.

Now let us look at foreign ores. How do they get into the picture? That gets back to the story of making iron out of the dirt from your backyard—economics. If high-grade foreign ores can be brought into the country to make steel as cheaply as, or cheaper than, by taconites, they will be so used. In addition to costs, however, there is the sheer question of needing the tonnage to make up the deficit in our own ore production.

Let me quote to you from the report of the President's Materials Policy Commission:

"During the next quarter century, there will be marked shifts in the sources from which the steel mills of the United States will draw their supplies of ore. Production from high-grade reserves in the Lake Superior region must eventually decrease; production from taconite may be able to offset this decline, leaving output of the Lake Superior region close to the present level of 90 million tons. Expansion in consumption can be achieved only through larger imports. Shipments from Canada and Venezuela in a volume approaching 65 million tons could meet the probable requirements and it is likely that such a volume of shipments can eventually be attained."

To enable you to appreciate this statement, let me show you two graphs outlining the foreign ore situation, past, present, and expected in the future. Slide No. 6 shows this by tons. You will note how our iron-ore requirements must rise to meet the figures for 1975 estimated by the President's Commission. Slide No. 7 shows this picture by percent. You will note how foreign ores go from 7.7 percent in 1950 to an expected 37 percent in 1975. Incidentally, note the drop during World War II—that is what the submarines caused and is something to be reckoned with in time of war.

The chief sources of foreign ore are expected to be Labrador, Liberia, Venezuela, and Brazil. In this connection, you have heard much of Labrador ore. As shown on slide No. 8, this is a newly discovered body of ore in Canada, located in Labrador and upper Quebec about the area of the tree line between Hudson Bay and the Atlantic Ocean. This project, too, will cost close to $200 million to build, requiring a railroad 365 miles long, the building of 2 towns in the wilderness, a large shipping dock on the St. Lawrence River, and large boats.

You can see for yourself how necessary the St. Lawrence Waterway becomes, and how it is just as much a necessity for Labrador ore as the Soo Locks are for the Lake Superior ore. It also becomes apparent how dangerous it would be to bring this ore to the Atlantic coast for inland shipment in time of war.

With two world wars depleting our ore supply and with future demands ever increasing, the steel industry is keenly conscious of the ore problem facing our country and is trying to do something about it.

What does it all mean?

1. It means that we must beneficiate our low-grade iron ores.

2. It means that we must go to foreign sources to supplement our own ore supply.

3. It means a big investment, higher costs, higher priced steel, and the need for the St. Lawrence Waterway.

4. It means the end to the talk of America's inexhaustible resources. At one time we had enough raw materials to take care of our needs and to supply other parts of the world; but that is no more.

(5) It means that we of the United States, comprising 6 percent of the population of the world with 5 percent of the land, who have been trying to help care for the material wants of the other 94 percent possessing 95 percent of the land, should take another good look at that policy. This situation becomes particularly significant when we realize that Europe and Asia together have over half of the known iron-ore reserves of the world, whereas North America has only 12 percent and, incidentally, the Soviets also have about the same percent as North America.

(6) It means that we now have become, and each year will be increasingly more so, like Great Britain and Germany, where our economy depends more and more on the raw materials of other parts of the world—and all the implications that go therewith.

As to the other major blast-furnace raw materials, that is, coal and limestone, there should be sufficient supply for the future, both for peacetime and for war.

Now let us look at the open-hearth raw materials, particularly oil and scrap.

As to oil, most of the open-hearth furnaces in the United States are built

for the burning of oil. To change to coal by way of gas producers or other means would be a major operation. It is my opinion, in event of war, as was true in World War II, the oil requirements would be so allocated so as to permit the steel industry to continue operating with its present types of fuel.

Now let us consider scrap.

You can remember from the last war, and even after that war, the importance of scrap. Bear in mind that scrap used in steel plants roughly can be divided as follows: 60 percent home scrap, or the scrap that keeps circulating in the plant and never leaves it; 20 percent from steel fabricators' plants arising from the current production of steel; and the other 20 percent is old scrap that comes from discarded machinery, wrecked buildings, etc., which I call "steel of the past." It is the availability of this "steel of the past" that determines the excess or shortage of scrap for the steel plants. Mr. Charles M. Parker, of the American Iron and Steel Institute, in his book, entitled "Steel in Action," estimates that the average time for the bulk of such steel to return to the steel plants is about 33 years. Now, when we realize that before many years we will be entering that part of the cycle where the "steel of the past" will be coming mostly from the 1930 depression period, at which time steel production was far below normal, and when you realize that the steel industry by its expansion is ever demanding more scrap, that greater durability has lengthened the life of steel, that allow contamination is reducing the amount of the scrap that can go into carbon steel, that a large amount of steel goes into light consumer products that cannot be reclaimed, that the increased use of electric furnaces is demanding more scrap, that much of the steel provided for munitions will never be recovered as scrap, all of these factors point to the high probability that there will be a deficiency of scrap for quite some years hence, at full operations.

Next to consider are the 15 principal nonferrous and ferro-alloying metals used in the steel industry, which, in alphabetical order, are aluminum, boron, columbium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, tin, titanium, tungsten, vanadium, and zinc. Of these 15 metals only 4—boron, molybdenum, titanium, and vanadium can have their full requirements met from mines within the borders of the United States. The other 11 must be supplemented, in part or entirely, by foreign sources. Five of these metals—aluminum, copper, lead, tungsten, and zinc have a substantial part of their requirements met by the raw material resources of this country; the next 3—cobalt, columbium, and manganese—must come almost entirely from abroad; the last 3—cromium, nickel, and tin must come entirely from foreign sources.

It should be thoroughly appreciated that unless these nonferrous and ferro-alloying metals are available, we can make few, if any, of our war steels; and without them much of our steelmaking capacity would be useless.

Of all these metals, by far, the most important is manganese; and I would like to devote some discussion to it at this time.

As previously stated, the first modern steel was Bessemer. Yet, Sir Henry Bessemer was unable to produce a commercial product until Mushet, in 1857, introduced manganese into the metal. This also later proved to be the case with open-hearth steel. To this day we cannot produce volume steel without it. Bluntly speaking—no manganese, no volume steel. I cannot emphasize to you too much the importance of this statement.

In time of war, the procuring of manganese presents an extremely serious problem as can be realized from the statements I am about to make:

(1) Most of the manganese consumed in the United States is used by the steel industry. It enters the industry via blast-furnace ore and via ferromanganese in the steel-melting operations.

(2) In the world production of manganese ores, the United States is a very small factor—2½ percent in 1950. In contract, Russia is the largest producer—40 percent.

(3) Ninety percent or more of the ferromanganese produced in the United States is from rich foreign ores.

(4) There is not a known large body of high-grade manganese ore within the borders of the United States.

(5) On the other hand, we have ample manganese in our low-grade ores. Unfortunately, after several decades of research and effort by the United States Government and others, not a commercial method has yet been developed to process most of the low-grade manganese-ore deposits in the United States. Several methods are now in the laboratory and pilot-plant stage.

If, through these methods now under study, we can develop the necessary processes commercially; and if we are willing to pay the penalty of using low-

grade ores, varying in manganese content from 1½ percent to 12 percent, there is potentially enough manganese in the lean ore bodies of this country to supply it for over 100 years. But, as yet, we do not have the answer for a commercial process. In nothing I say do I wish to minimize the very precarious position of this country in respect to manganese.

(6) The manganese situation in this country has become increasingly serious because our former main source of rich manganese ore has vanished, viz: Russia, as seen on slide No. 9.

I now have covered the essential raw materials for the steel industry in the United States.

I also have been asked to discuss the steel industry of the Soviet and communistic world in comparison to our own country and the free world—particularly from the raw-material standpoint.

In this connection, I want to state that information on Russia and their satellites is difficult to obtain, that I do not pose as an expert on the subject, and that there probably are people in this audience better informed thereon than I am. However, I will present to you the situation as I have found it from three standpoints:

(1) The relative growth of the Soviet steel industry compared to that of the United States.

(2) The location of the Soviet's major steel-producing centers.

(3) How self-contained are both countries as well as the communistic world and free world in respect to raw materials essential to the steel industry?

(1) THE RELATIVE GROWTH OF THE SOVIET STEEL INDUSTRY COMPARED TO THAT OF THE UNITED STATES

You will note on slide No. 10 that, prior to World War II, Russia reached its peak of production of 20,500,000 tons in the year 1939. Thereafter, particularly with the advent of the war, its production dropped and it was not until 10 years later, in 1949, that it recovered its lost position. Since that time, the increase has been steadily upward further supplemented by the steelmaking capacity of its satellites.

More comprehensive comparison probably can be obtained by comparing Russia's production as a percentage of that of the United States, as shown on slide No. 11. You will note that at the beginning of World War I, that is 1914, the production of Russia was 18½ percent of that of the United States. With the war and subsequent internal disorders, the output markedly declined. It was not until 17 years later, 1931, that it regained the same percentage. Then, through the "Commie cuddling" years of the thirties, Russia's percentage increased at a tremendous rate, averaging over 35 percent with a maximum of 62 percent in the year 1938. With World War II the percentage again dropped and it has never regained that position, being currently 30 percent. One disconcerting fact, however, is to see how rapidly Russia has been gaining on the United States since the year 1942. In that year its output was 10 percent of that of the United States. From there, Russian production has grown consistently and rapidly until now, as previously stated, it is about 30 percent of that of the United States.

To broaden the picture let us now compare the output of the communistic world with that of the free world. That figure is 22 percent.

(2) THE LOCATION OF THE SOVIET'S MAJOR STEEL PRODUCING CENTERS

The major steel producing centers of Russia are shown on slide No. 12. In most of these areas shown, there are steel plants and adjoining ore and coal bodies, either near at hand or within several hundred miles. However, between operations in the Ural Mountains and those in Siberia, there has been and may still be some long-haul interchange of ore and coal; however, we understand steps have been and are being taken to improve that situation. The distance between each of these areas is about equal to that from New York to Denver. Looking at the map, you will note that 35 percent of their production is in the Ukraine area adjoining the Black Sea; 30 percent in the Ural Mountains; 10 percent in Siberia just near the borderline of Mongolia; and 25 percent in scattered areas not shown on this map. While Manchuria's tonnage is not included in the percentages herewith given, we have shown that steel production in Manchuria as representing about 5 percent of that of all Russia.

(3) HOW SELF-CONTAINED ARE BOTH COUNTRIES AS WELL AS THE COMMUNISTIC WORLD AND FREE WORLD IN RESPECT TO RAW MATERIALS ESSENTIAL TO THE STEEL INDUSTRY?

Just how self-contained are the United States and Russia as well as the free world and the communistic world is shown on slide No. 13, for 10 major raw materials essential to the steel industry. Note that both sides, in all cases are self-contained in coal and limestone.

Considering the United States and Russia alone, however, we find that the United States is not self-contained in 7 of them; that is, iron ore, manganese, aluminum, nickel, chromium, tin, and cobalt. On the other hand, Russia is self-contained in 5 of the 8; that is, in everything except molybdenum, tin, and cobalt. Note that deficiencies in tin and cobalt is common to both.

On the other hand, comparing the free world to the communistic world, the free world is self-contained in everything, whereas the communistic world is lacking in molybdenum, tin, and cobalt.

However, we should not allow the latter comparison to lull us into a false sense of security because there always are possibilities of political changes and, particularly, when a war is on, there is always a question as to how much the faraway raw materials can be brought into use. I am inclined to believe that we would be realistic by comparing the resources of the United States with Russia alone. And, in this case, you will see that we have a much greater raw material problem than Russia.

However, one important difference should be borne in mind, namely, that much of the steel industry in Russia is geared to a war machine. Putting it another way, this country attempts to care for both butter and guns, while Russia is mostly concerned with guns alone. Do not underestimate the potential of Russia. The Germans did so in the last war.

We then come to the question—what should we do about our deficiencies? And that brings me to the conclusion of my talk where I propose to present to you, recommendations, as I stated at the outset of my talk, that should be taken seriously and acted upon promptly for the safety of our country. These are the recommendations:

RECOMMENDATIONS

(1) Go the limit to defend the Soo locks. Let me say, that to a novice in military affairs, this defense when viewed from the deck of an ore vessel en route through the Soo locks, looks hopelessly inadequate.

(2) Build the St. Lawrence Waterway and start its construction immediately. Let me point out to you that in the Resources for Freedom Report to the President, it is estimated that in 1975 we will need 70 million net tons of foreign ore—and that is more ore than was ever brought through the Soo locks prior to World War II. While some of this ore would be used on the Atlantic coast, and hence would not go through the waterway, the tonnage herein quoted does give a picture of the magnitude of the expected foreign ore movement. Just as the Soo locks opened the bottleneck for the ore movement from the West, the St. Lawrence Waterway should open the bottleneck for the ore movement from the East. Furthermore, when you consider the time required to build this waterway, you can see that we will be appreciably along the next 25-year period by the time it is completed—and by that time huge quantities of foreign ore movements should be underway. The opponents to the seaway assert that the Labrador ore, in time of war, could be shipped by rail down to the seacoast plants to supplant the loss of the foreign ore. Let us assume that is so; that is not the whole picture. Labrador can be made to produce many more tons than these eastern plants could take and the large excess of Labrador ore, so produced, could go to the inland plants, which had been depending upon it in peacetime.

I would not want to say that those opposing this waterway are unpatriotic or do not have the defense and welfare of the country at heart; but I cannot help but feel that they do not understand this world picture of iron ore and do not realize the absolute necessity of this St. Lawrence waterway in time of war. And let me say to you men, that all the Joint Chiefs of Staff, the Secretary of State, Secretary of Commerce, and every President of the United States since Harding: Harding, the economy-minded Coolidge, the engineer-trained Hoover, Franklin Roosevelt, and Truman—all have advocated this waterway; and it behooves you men of the Armed Forces to insist upon the immediate construction of the St. Lawrence waterway in order to avoid the hazard of a serious ore shortage that might occur in a most critical period of an emergency.

(3) Encourage the development of magnetic and nonmagnetic taconites and the subsequent building of plants to process this ore. We should not tamper with fate by waiting for a war to do this job on nonmagnetic taconites—we will need this ore. We should protect ourselves with these plants as well as with Labrador ore.

(4) Encourage the stockpiling of a year's supply of iron ore on the south shores of Lake Erie near a railroad head, such as, at Cleveland or Ashtabula. This stockpile can feed the plants of Ohio and the East in case of a disaster at the Soo. Furthermore, in peacetime, this stockpile could be tapped to overcome ore shortages at the blast furnaces during an abnormally short shipping season or similar circumstance.

The Chicago district could probably best be taken care of by railing directly from the Lake Superior ore mines.

When business drops off, the ore mines should be kept going to build up this stockpile. The product also could be stockpiled from the proposed magnetic and nonmagnetic taconite plants.

(5) At the upper lake ports encourage the replacing of all wooden trestle approaches from the rail lines to the shipping docks as well as all wooden shipping docks. It does not take much imagination, when you see these wooden structures, to realize how easily a fire might be started and to picture the damage that could result. The match of a saboteur here would create almost as much havoc as a bomb at the Soo locks.

(6) Encourage the modernizing and enlarging of the Escanaba loading facilities and the expanding of the rail facilities leading thereto. This is the one iron ore loading dock on this side of the Soo locks and every possible utilization of it should be made.

(7) Encourage the development of our more desirable and large tonnage lower grade manganese ores and the subsequent building of plants to process them. No word I say can exaggerate the importance of pushing this manganese project into immediate action. In the meantime, the present policy of maintaining a large stockpile of rich foreign manganese ore should be continued.

(8) Encourage the stockpiling of all other nonferrous metals used in the steel industry, requiring foreign ores, in part or in total, to insure that, if the foreign sources were cut off, we still could prosecute a long war. This program is very important. In fact, we should encourage the development of foreign ore bodies.

A searching review of the present stockpiling and control program may now be in order. The incentive for consumers of strategic raw materials to prospect for new foreign sources is limited when all or most of the products of their pioneering go into a common pool.

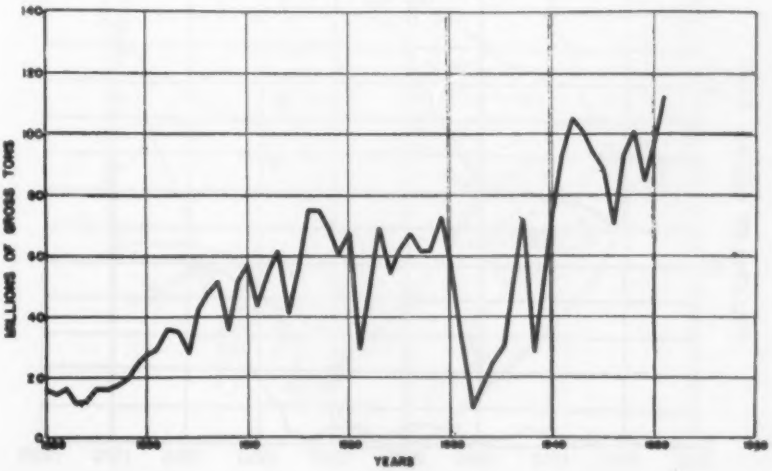
(9) The future availability of scrap depends on "the scrap steel of the past." I cannot help but agree with the President's Resources of Freedom report that "The share of scrap in the metallic materials fed to furnaces will therefore decline and the share of pig iron will have to rise. This will require a corresponding increase in the supply of iron ore, coke, and limestone. And it will necessitate a substantial addition to investment in facilities for mining, preparing, and transporting ore, in coke ovens, and in blast furnaces."

Exporting of scrap should be prohibited. Scrap is just as vital a source of iron units as the ore mines.

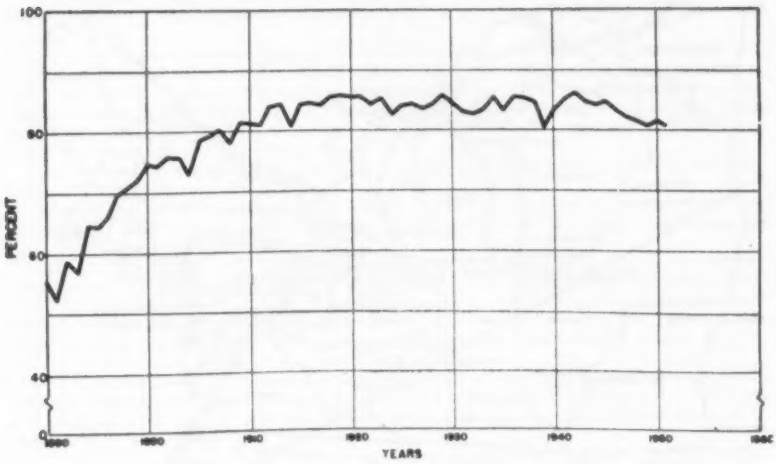
(10) If it has not already been done, a group of well-informed steelmen, in conjunction with corresponding officers from the Armed Forces, should evaluate carefully all of the available information on Russia's steel position. This study should point out both their strength and weaknesses to form the basis for future plans of our country.

In conclusion, let me say that you may perfect better tanks, improved artillery, construct atomic-powered submarines, hydrogen bombs, and many ingenious devices made possible by modern science, but how much will they avail without the backbone of war—steel. First be sure you will have iron ore, scrap, manganese, and all the nonferrous metals needed to produce your war steels. Without them we are lost.

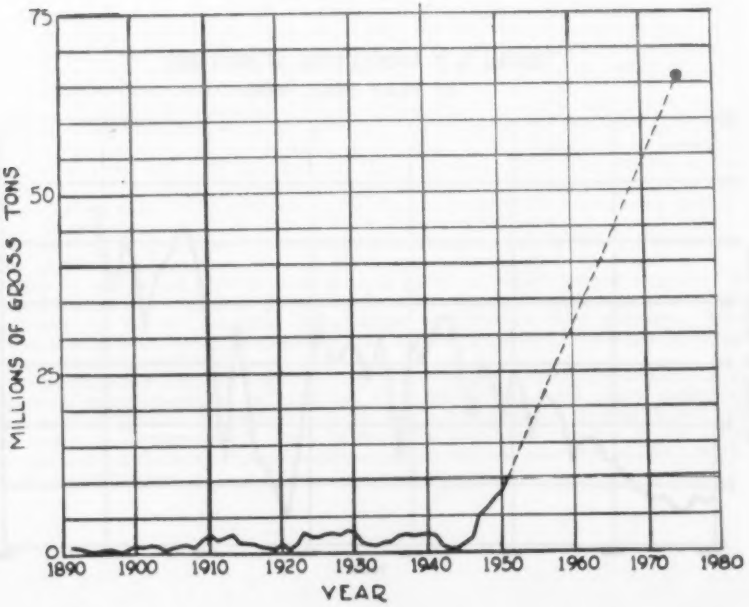
TOTAL U. S. PRODUCTION OF IRON ORE
BY YEAR SINCE 1890

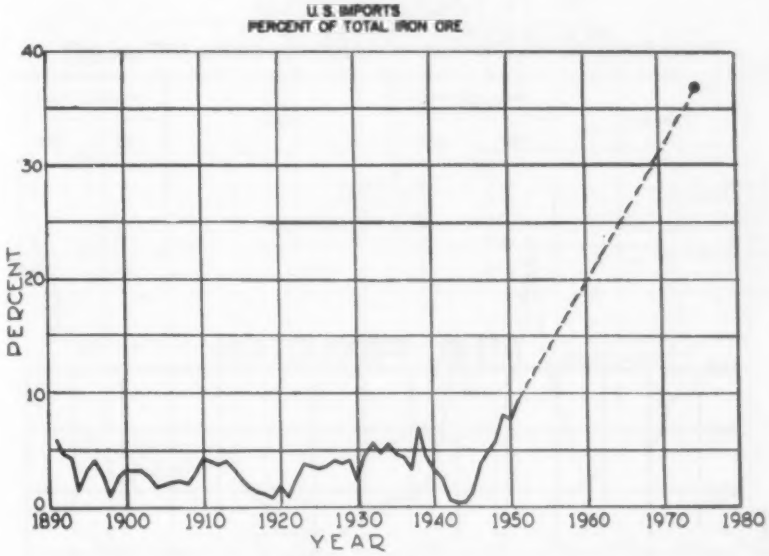


LAKE SUPERIOR DISTRICT
PERCENT OF TOTAL U. S. IRON ORE PRODUCTION



U. S. IMPORTS OF IRON ORE



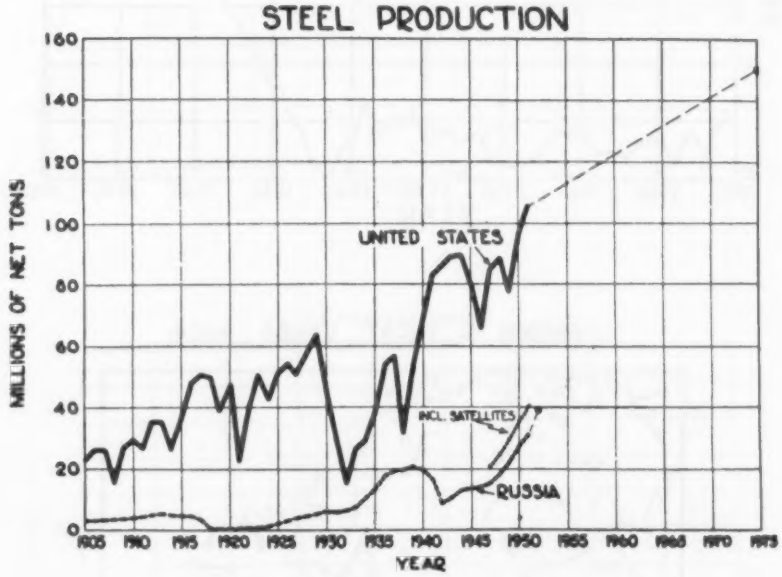


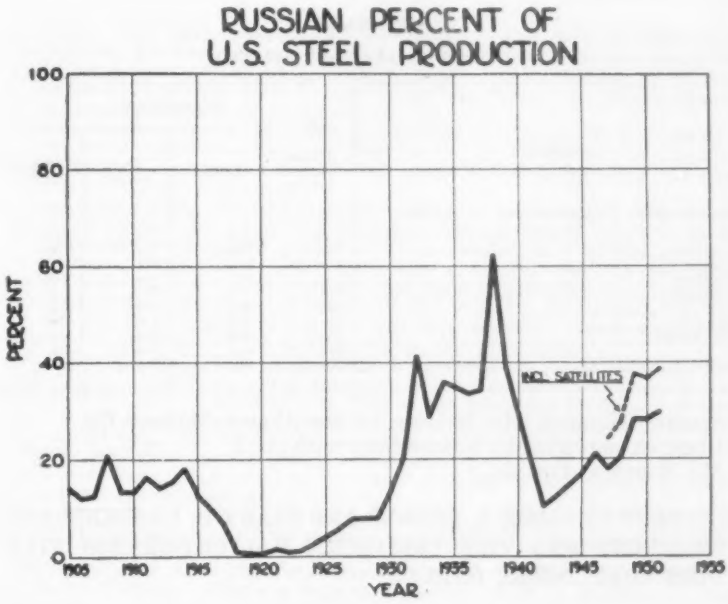
LABRADOR & GREAT LAKES AREA

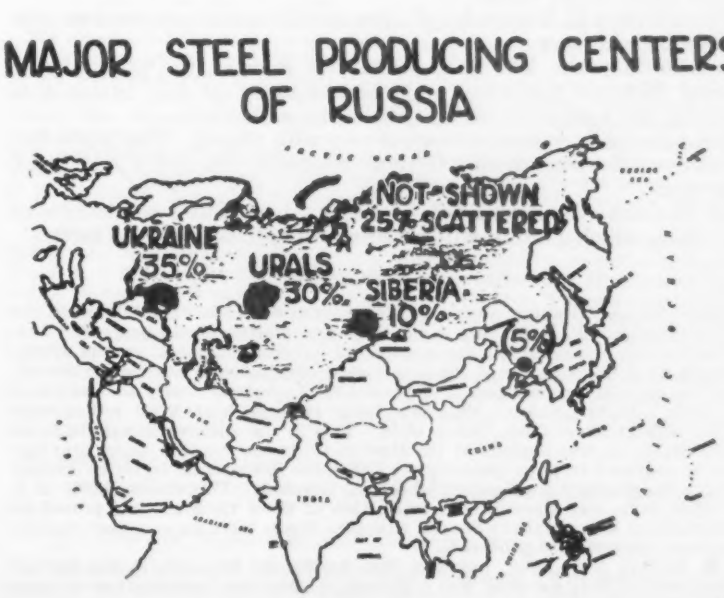
SLIDE No. 9

United States imports of manganese ore for consumption, 1937 and 1950

Country	Percent of total		Country	Percent of total	
	1937	1950		1937	1950
Russia	41.8	3.6	Egypt		2.8
Gold Coast	29.2	15.4	Mexico		1.8
India	8.2	36.0	Chile		.4
Union of South Africa	0.	24.9	Philippine Islands		.3
Brazil	8.0	6.9	Other sources	0.2	1.2
French Morocco		1.3			
Cuba	12.6	5.4	Total	100.0	100.0




RUSSIAN PERCENT OF
U. S. STEEL PRODUCTION
100
80
60
40
20
0
PERCENT
INCL. SATELLITES
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
YEAR


MAJOR STEEL PRODUCING CENTERS
OF RUSSIA
NOT SHOWN
25% SCATTERED
UKRAINE
35%
URALS
30%
SIBERIA
10%
5%

SLIDE No. 13

Self-containment of raw materials

Material	Self-contained			
	United States of America	Russia	Free world	Communist world
Coal	Yes	Yes	Yes	Yes.
Limestone	Yes	Yes	Yes	Yes.
Iron ore	No	Yes	Yes	Yes.
Manganese	No	Yes	Yes	Yes.
Aluminum	No	Yes	Yes	Yes.
Nickel	No	Yes	Yes	Yes.
Chromium	No	Yes	Yes	Yes.
Molybdenum	Yes	No	Yes	No.
Tin	No	No	Yes	No.
Cobalt	No	No	Yes	No.

Senator MALONE. Mr. Roemer, of the Sharon-Mallory Co. I believe you have Mr. Vandenburg with you?

Mr. ROEMER. Yes, sir.

TESTIMONY OF JAMES A. ROEMER AND FRANK H. VANDENBURGH, PRESIDENT AND VICE PRESIDENT, MALLORY-SHARON TITANIUM CORP., NILES, OHIO

Senator MALONE. Will you identify yourself and Mr. Vandenburgh for the benefit of the record?

Mr. ROEMER. James A. Roemer, president of Mallory-Sharon Titanium Corp., Niles, Ohio.

This is Frank H. Vandenburgh, vice president and general manager of the same company.

Senator MALONE. You have heard, Mr. Roemer, the testimony of General Metzger yesterday and the testimony of Mr. Smith this morning, the testimony of Mr. Richards, and others.

Just proceed in your own way, if you will, please. You know the objective of the committee. Give us whatever you feel would be of value to us.

Mr. ROEMER. We have a brief summary here that I would like to read from, which I think will give our background, and so forth:

PART I. A BRIEF HISTORY

Mallory-Sharon Titanium Corp. was incorporated March 20, 1951, under the joint ownership of P. R. Mallory & Co., Inc., and Sharon Steel Corp. The new corporation was organized to manufacture and sell titanium metal and its alloys.

Sharon Steel Corp. is one of the major steel companies in the United States. It has an excellent reputation as a producer of specialty steels in sheet and strip form. Mallory-Sharon Titanium Corp. is located at Niles rolling mill division, Sharon Steel Corp., Niles, Ohio. This is the sheet-rolling division of Sharon Steel. It was obvious at the time of incorporation that sheet titanium would be required in large quantities. The Niles rolling mill facilities seemed ideal for the production of quality sheets of titanium. This choice, made at a time when little was known about production of sheet titanium, has proved to be an excellent one. Mallory-Sharon titanium sheets have an excellent reputation among the airframe producers.

P. R. Mallory & Co., Inc., has long been known for its work in the field of special metals. This company was a pioneer in American manufacture of tung-

sten wire. They have worked with the more rare metals, such as tantalum and molybdenum, for many years. Titanium, as an addition to copper alloys, was a familiar element. When Dr. R. S. Dean, in his work at the Bureau of Mines, set up the Kroll process in the United States, some of the first ductile titanium powder produced was tested by the Mallory Co.

Early experimentation with this powder and fabrication of test pieces by powder metallurgy methods led to the conclusion that the material had excellent possibilities as a structural metal. Dr. Dean is still acting in a consulting capacity for Mallory-Sharon.

Negotiations with various Government agencies were started early in 1946 to develop methods for fabricating titanium. The interest of the Navy Bureau of Aeronautics in proposals submitted by the Mallory Co. resulted in a contract which started in 1947. The work done under this contract led directly to the conclusion that the metal should and could be produced on a large scale. Accordingly, after 4 years of development and research, the Mallory Co., lacking fabricating equipment of the size and type required, joined with Sharon Steel in the formation of the Mallory-Sharon Titanium Corp.

Niles Rolling Mill had early in 1950 rolled sheets from ingots supplied by the du Pont Co. The Niles rolling experiments were successful enough to prove that their know-how and equipment were ideally suited for production of titanium. It was, then, a natural result of the background of both companies that they should pool their efforts and resources and form the present corporation.

Briefly, that gives the background of our company.

The next thing we would like to touch on is our supply of raw material, which is the titanium sponge:

PART II. MALLORY-SHARON TITANIUM'S RAW MATERIAL (SPONGE) SITUATION

Mallory-Sharon Titanium Corp. has fabricating facilities for melting and rolling of titanium. They are entirely dependent on E. I. du Pont for their raw material, titanium sponge. Their melting and rolling capacity far exceeds the supply of sponge available to them. It is our understanding that the distribution of Du Pont's sponge production is approximately as follows:

70 percent to Rem-Cru Titanium, Inc.
10 percent to Mallory-Sharon Titanium Corp.
10 percent to Republic Steel.
10 percent to miscellaneous sources (additions to steel, etc.)

We assume that this distribution was set up by du Point and the Government agencies on the basis of historical use of the raw material. Of the companies dependent upon du Pont for sponge, Rem-Cru was first to reach quantity production as is indicated by the above distribution pattern. Lacking a better reason, this solution was probably fair at the time. It is the considered opinion of Mallory-Sharon that the time has come to reconsider this distribution pattern on the basis of the quality of ingots and sheets produced by Mallory-Sharon Titanium. Exact reasons for this suggested changed are discussed in detail in the sections labeled as follows: "Part III. Melting Program"; "Part IV Scrap Utilization Program."

It should be mentioned in concluding this sponge supply discussion that repeated attempts to obtain sponge from other producers have met with failure. Recently, in discussion with representatives of the Metals and Minerals Advisory Board, it was specifically requested by Mallory-Sharon Titanium that sample quantities of sponge be obtained for us to attempt melting experiments on low-quality sponge produced at Henderson, Nev. Mr. James Long is at present trying to work this out but no action has yet been taken.

Mallory-Sharon Titanium is also working with Japanese producers of titanium sponge in order to develop another reliable source of raw material. It is believed that ultimately this will be a good source but not for some time to come for large quantities.

So much for our sponge picture.

On our melting program we would like to give a little background also:

PART III. MALLORY-SHARON TITANIUM'S MELTING PROGRAM

As mentioned in part II, some of the detailed reasons for requesting a reallocation of raw material will be discussed in this section. Some historical background will serve to better outline Mallory-Sharon's present position and program.

Obviously, any successful venture into the metal-producing business must be based on the following criteria:

1. A continuing source of quality raw material.
2. An economical melting method which produced high-quality ingots.
3. Recirculation of generated scrap.

Those three criteria are inseparably interrelated, e. g., the melting method should be suitable for scrap remelting as well as melting virgin material, both without contamination.

Mallory-Sharon spent much time and money on the development of the induction melting method for titanium for the following reasons:

1. A completely homogeneous molten bath can be obtained.
2. Pouring from furnace to ingot mold seemed feasible. (This should lead to quality ingots.)
3. Scrap utilization could be readily accomplished.
4. Relatively inexpensive power source (A. C.).

This method was finally abandoned because of a lack of suitable crucible materials. Graphite was the best of many tried, but sufficient control over the solution of this element in titanium could not be exercised.

Accordingly, the next method tried was the electric arc using a nonconsumable electrode of graphite. A production size (10-inch diameter) furnace was built and many ingots made. Though control over carbon contamination was established, the ingot yield, due to layer type melting, was very low. It was not uncommon to lose 30 percent of the ingot in scalping prior to forging or rolling. This seemed excessive when the cost of the raw material was considered.

Senator MALONE. Right at this point, that means you lose 30 percent in scrap?

Mr. ROEMER. Right, in conditioning the ingot so it would be of the right quality to go ahead and process further.

Senator MALONE. You lose 30 percent in that process; then do you lose anything further in the scrap?

Mr. ROEMER. That is correct. That was just on the conditioning of the ingot. [Reading:]

Also, alloy production in such a furnace is difficult, though possible, and scrap remelting, particularly sheet trim and massive scrap, is almost impossible without expensive preparation of the scrap.

During all of this above-described work, continued experimentation with other melting methods was continued. Early in 1951, it became apparent that a consumable electrode method, using a d. c. arc, was not only feasible but produced better ingots more economically, since power losses due to cooling a nonconsumable electrode were eliminated. Small laboratory furnaces were in operation, and design criteria were established. When the Bureau of Mines announced their method of double melting using a consumable electrode, this was tried on titanium and found to be very successful.

During the past year, Mallory-Sharon has designed and put into operation three furnaces for this method of melting. Ingot quality has been excellent with very little preparation required for forging and rolling. This melting method has been named Method S by Mallory-Sharon. Briefly, Method S involves compaction of titanium sponge, joining of these compacts into a sufficiently long electrode by welding and feeding this electrode into a copper crucible where an arc is struck to an ingot. The resulting ingot is remelted in a second and larger crucible to produce the finished ingot. Methods for the utilization of all types of scrap have been devised. These methods will be outlined in detail in part IV titled "The Scrap Utilization Program of Mallory-Sharon."

Ingots made by Method S have proved to be homogeneous, sound, and free from gas holes, and possess an excellent surface. It is rare to lose as much as 5 percent of the ingot weight in ingot conditioning. Alloy production, with excellent chemical homogeneity, has proved to be possible. Contamination by O_2 and N_2 is held to a very low value and carbon content is no more than present in the sponge.

Although Method S has proved to be the most satisfactory of production melting so far developed, much can still be done to improve the melting process. Mallory-Sharon will continue to develop new methods and processes to improve ingot quality and yield and to reduce the cost of melting.

PART IV. PROGRAM FOR THE UTILIZATION OF SCRAP

As mentioned in part III, the recirculation of scrap is a necessary factor in the growth of any metal industry. Mallory-Sharon has instigated a thorough program for the utilization of both internally and externally generated scrap. Since Mallory-Sharon has both induction and arc melting equipment available for use, they are uniquely suited to recirculate all types of scrap.

Equipment has been ordered for the cleaning and degreasing of scrap. This has proved to be the biggest problem in the utilization of turnings. Such turnings also must have the iron removed, and this equipment has been ordered.

Mallory-Sharon has also maintained active contact with outside sources who have suitable scrap on hand. Sample lots have been ordered and will be processed to determine if the analysis is as claimed.

Mallory-Sharon feels certain that all of its internally generated scrap will be utilized by the first of the year. Turnings and sheet scrap purchased from customers will be included. There are no problems involved in the utilization of scrap which cannot be surmounted, and Mallory-Sharon, realizing the importance of this phase of the titanium program, intends to do a real job of scrap utilization.

I might add here that for the month of September in our regular production we will have utilized about 5 to 6 percent of that production of scrap.

Senator MALONE. Then you are actually reclaiming a certain percentage of the scrap?

Mr. ROEMER. Yes.

Senator MALONE. How do you consider the future of regularly reclaiming scrap?

Mr. ROEMER. We figure that there is a very good potential to reclaim the major portion of all of the scrap generated in our plant, depending on the control and segregation of outside scrap, we feel that we can also utilize outside scrap.

Senator MALONE. Is it an expensive method? That is, does it compare with the reclaiming of steel scrap or is it considerably more intricate in process and does it involve more cost?

Mr. ROEMER. It is much different than the reclamation of steel scrap. There are many more technical problems to overcome; it has to be more highly segregated. You can't stand the different contaminants to the degree they could be tolerated in ordinary steel scrap.

Senator MALONE. But the expense in reclaiming the scrap—what I really meant to ask, or to get information on, is the money saved over new sponge material.

Mr. ROEMER. We can't answer that question at the moment, Senator. We take this position, that it is extremely important that scrap be recycled and used because by so doing you add to the supply of available sponge.

In other words, if we can regenerate 20 percent of scrap, it is like adding 20 percent to the sponge supply.

Senator MALONE. That is the important item at the moment.

Mr. ROEMER. And we feel, even if it costs us, let's say $4, $5, or even $6 a pound to reclaim that scrap, the position is that it would be worth that to augment the supply of titanium wrought product at a time when the Air Force is in such dire need of it.

Senator MALONE. And when the sponge is in short supply?

Mr. ROEMER. Yes. In that connection, on all of these programs we have developed this with our own facilities and have not had any Government funds awarded to us on the scrap program.

Senator MALONE. You are actually putting up your own money?
Mr. ROEMER. Yes.
Senator MALONE. That is an unusual procedure.
Mr. ROEMER. We might need some help later on. [Reading:]

PART V. A NEW ROLLING METHOD FOR TITANTIUM SHEETS

Realizing from their first experiences with titanium sheets that surface would be all important, Niles Rolling Mill developed a special method for the rolling of titanium sheets. This is a patented method (U. S. Patent 2,651,099, granted September 8, 1953). It involves the sandwiching of titanium between sheets of basic steel during the rolling process. The resultant sheet is remarkably free from defects, has a good finish, and has very uniform thickness tolerance as well as being flat. All of Mallory-Sharon's sheets are rolled by this method.

Continued effort is being maintained to improve the physical properties of both alloyed and unalloyed sheet rolled by Niles Rolling Mill for Mallory-Sharon Titanium Corp.

Present production is predominantly in the unalloyed material. This material is rolled at Niles Rolling Mill and is shipped in the hot rolled, annealed, and descaled condition. Gages down to 0.016-inch thick have been rolled in quantities of many tons per month. Uniformity of quality has been excellent. Conformity to specifications for 50,000 and 70,000-pounds-per-square-inch-yield-strength material can be maintained in any gage starting at 0.016-inch thick.

We have various alloying programs that we have under development and in order to expedite those, we have recently completed and dedicated a new research building. That is devoted exclusively to research on titanium and titanium base alloys. [Reading:]

PART VII. A NEW SALES, ENGINEERING, AND RESEARCH FACILITY DEVOTED EXCLUSIVELY TO TITANIUM

On June 25, 1953, was dedicated a new building to house the sales, engineering, and research activities of Mallory-Sharon. It is believed that this is the first building of its kind devoted exclusively to titanium. The sales, engineering, and research activities are headed by 12 graduate engineers, with additions to this group contemplated in the very near future.

Complete laboratory melting and rolling equipment is presently housed in this building. Complete physical testing equipment is also available. A new metallographic laboratory is included as is office space for the staff. A machine shop for the preparation of specimens is operating. A chemistry laboratory devoted exclusively to control of the melting and rolling process is installed and operating. The building is air-conditioned, furnishing excellent environment for spectographic and X-ray facilities to be installed soon.

The proximity of three important groups (sales, engineering, research) has led to very close correlation of activities. This is very important to customers and to those requesting information. The production group is within short distance of the new building which also minimizes communication problems.

Needless to say, Mallory-Sharon is proud of the sound approach taken to solve the problems faced when beginning a new industry. We feel that our methods and equipment are good, and they will be made better.

Senator MALONE. You heard the witnesses, from General Metzger, through Mr. Richards of Republic Steel, about the demand providing confidences with the established in the producers and designers that the material would be available when needed.

Do you agree with those witnesses?

Mr. ROEMER. We concur wholeheartedly with the position that General Metzger has taken, and we concur wholeheartedly with the position that has been taken by Mr. Richards of Republic Steel.

We feel exactly as he does. We have the melting capacity available; we have rolling facilities; we feel that our background and know-how

is the melting, rolling, and fabricating of metals. We believe there are people much better qualified than we to produce titanium sponge.

Senator MALONE. You do believe also, I think, that the market will demand whatever is available of the proper material in titanium up to 150,000 or 100,000 tons a year to which General Metzger and Mr. Richards have alluded.

Mr. ROEMER. We feel that way, and I think Mr. Richards mentioned the remark about some of the aircraft people in that regard.

I think at Wright Field, in an open meeting, one of the aircraft engineers stated that they could afford to pay $30 a pound to save a pound, even in commercial aircraft, but they wouldn't pay it in all probability. They wouldn't pay, let's say, $20 a pound, but they might pay $10 a pound, so there is a definite interest on the part of the aircraft people for the use of titanium in commercial aircraft.

Senator MALONE. It would be an almost unlimited use if the commercial aircraft and commercial moving equipment went into the business of using titanium?

Mr. ROEMER. We feel that way.

Senator MALONE. Do you have any knowledge as to the strategic materials and minerals that titanium may be a substitute for in whole or in part?

Mr. ROEMER. I don't have any specific knowledge of that, with the exception of the phase that Mr. Richards touched on where we know that titanium has been used to replace columbium in high grade stainless steel alloys.

Senator MALONE. In the production of alloys, then, there are certain fields that titanium takes the place of other scarce materials?

Mr. ROEMER. That is correct.

Senator MALONE. You are not just familiar with them?

Mr. ROEMER. I am not familiar with the details, not qualified to answer that.

Senator MALONE. Is there anyone in your organization qualified to prepare a statement on that?

Mr. ROEMER. We could check that with the people at Sharon Steel Corp.

Senator MALONE. Will you do that, providing they have the necessary information, and prepare a paper or a brief and send it to the chairman of the Senate committee?

Mr. ROEMER. Yes; I will do that.

(The information referred to follows:)

MALLORY-SHARON TITANIUM CORP.,
Niles, Ohio, November 4, 1953.

Mr. JEROME S. ADLERMAN,
Counsel, Minerals, Materials, and Fuels Economic Subcommittee,
United States Senate, Washington, D. C.

DEAR MR. ADLERMAN: Titanium is being substituted for columbium as a stabilizing element in the manufacture of various types of stainless steel. Further, in stainless steel containing 8 percent nickel experimental heats are being made with 6 percent manganese and 4 percent nickel, the manganese substituting for one-half of the nickel.

The above pertains to operations at Sharon Steel Corp., Sharon, Pa. If it is necessary to have more detailed information we will try to get it for you, if possible.

Yours very truly,

JAMES A. ROEMER, *President.*

Senator MALONE. Do you have any further statement or anything you would like to submit for the record?

Mr. ROEMER. I have no further statement.

Perhaps Mr. Vandenburg might have some things he would like to say, because he has a much better knowledge of the technical and sales details than I do, and he may have something he would like to say.

FUTURE UNLIMITED

Senator MALONE. Mr. Vandenburg?

Mr. VANDENBURGH. Yes. On the whole titanium picture we feel that the future is practically unlimited, and just 2 or 3 years ago I saw a survey that was made by a company interested in getting into the picture.

They had plotted the possible uses of titanium against costs, and it is entirely possible if we get this metal down to, let's say, $3 or $4 a pound, that the industry would be as large as the stainless steel industry is today.

I would almost agree with the statement you made some time ago that it would practically revolutionize the entire transportation industry, from the standpoint of speed and fuel and road development, everything. It could really have a big impact upon that industry.

Senator MALONE. You mean if it gets down to say $3 a pound, on sponge you are speaking about?

Mr. VANDENBURGH. The raw product, the sheet, rod, and bar.

Senator MALONE. The testimony yesterday was not too favorable to an immediate reduction of a great amount of the cost.

What do you believe, with the information you have, as to the rolling an fabricating of the metal? We have had some considerable detailed testimony that the original raw material might come well below $5 a pound.

What do you think about the possibility of taking it from there and having a reduction in the cost which will make it available to the market?

Mr. VANDENBURGH. Well, it is my feeling that to get the price down there are two main factors: The cost of the sponge and our ability to recycle scrap.

If the price of sponge were able to be cut in half——

Senator MALONE. $2.50. It was testified yesterday that might be done.

Mr. VANDENBURGH. If we can have that sponge of good quality and recycle our scrap, I feel that we can very readily approach a $5 a pound figure for rod and bar.

Senator MALONE. That would really be revolutionary.

Mr. VANDENBURGH. I think so.

Senator MALONE. You are in the business, and you feel that an additional $2.50 in quantity, that you could do it for that figure?

Mr. VANDENBURGH. That is right; larger melting facilities and special-handling equipment, and things like that will come as you develop.

Senator MALONE. Then this harks back to the original statement the chairman made. He was in the engineering business for 30 years, but not in the steel business, so when you get outside of your own business you can talk freely.

From the conversation I had yesterday, from various sources of reliable people who have the know-how, and with titanium at $15 a pound—it was $45 or $44 a pound during World War II, as you probably know, and had a very limited use—but we are now at the point in the use of titanium where there is reluctance on the part of designers of military equipment to come to Congress and ask for the money.

In order to get the full impact in the mills, if they did demand it and did let the contracts and got the material, it was the opinion of the chairman—not being responsible for an opinion on steel, but only correlating information—that where the logs were jammed no one would order enough to get into production so that it could be cheapened through volume production.

Is that what you mean?

Mr. VANDENBURGH. I believe that 100 percent.

Senator MALONE. In other words, we thought this committee might furnish the medium and in some way encouraging production. If the 5 men on the subcommittee and the 13 members on the full committee became convinced that they might have some influence on the Senate floor in encouraging the changeover from a minimum of material being manufactured, and an additional capacity in every one of our steel mills, to use more of it, with all the designers hungry for it, then immediately your costs are cut, so that you get three times the amount of the material for what it is costing now.

That testimony is very interesting to me, coming from an expert in the steel business.

COST WILL REMAIN HIGH

Mr. VANDENBURGH. Titanium will never, as I see it, be a cheap metal. It is difficult to handle. The extraction as we know it is complicated, but we are right at the beginning of this industry.

We know a great deal more now than we did a year ago, and I think our predictions for the future can be quite accurate now with regard to decreased manufacturing costs and volume production.

Senator MALONE. Further than that, where there is no prospect of using it in war material outside of planes at the present time, suppose you had the material available to make tanks where the speed of the tank and the soundness of it would be 30 percent lighter and be just as impervious to injury of the people inside the tank, then wouldnt' they make the tank out of titanium, to a large extent?

Mr. VANDENBURGH. I am sure if you would check with Ordnance, they would give some rather detailed planning along that line, particularly with the thinking of a great deal of that type of material having to be airborne.

It is just as important to have lightweight tanks as to build an extra airplane.

Senator MALONE. You have your guns, your artillery. I am trying now to think ahead, because this is so new. When it is available, wouldn't farm machinery and road equipment, trucks, and all that sort of thing contain a large amount of lighter, stronger material?

Mr. VANDENBURGH. As far as trucks, I would agree with that. As to farm equipment, I wouldn't think so, because there will always be a great spread between basic steel and titanium.

Senator MALONE. And even your equipment like a binder, or some other machinery that you run by fuel, it could be much lighter and use less fuel. Do you think there might be a place for that?

Mr. VANDENBURGH. I can't see that it would get that far.

Senator MALONE. But anything of the nature that you have mentioned, how many thousands of tons a year would that run into?

Mr. VANDENBURGH. I made the comparison with the stainless steel industry. I believe last year they did about 880,000 tons.

Senator MALONE. And you think titanium might eventually displace a very large amount of stainless steel?

Mr. VANDENBURGH. I doubt whether it would displace it. I think it will supplement it.

Senator MALONE. I used the wrong word, because when we talk about a new invention, displacing something, we often find that you use more of the same material, that you double up on the use of the new material.

That is a better way of phrasing it. So, if I gather the purport of your testimony, you think that the 100,000 tons per year, or the 150,000 tons per year, may be a very moderate, conservative estimate?

Mr. VANDENBURGH. I do.

Senator MALONE. Isn't the field wide open then for people who want to go in and take contracts for this material under conditions that have been laid down, have been explained here, and the contracts which have already been let? The producer is safeguarded from loss as they improve the processes.

What do you think ought to be done, if you were running this thing in Washington? I am trying to get some information for the people who are running it. There are 9 Senator who will have considerable to do with it, but there are 435 Congressmen too, but none of us have any real information. I can say that authoritatively. We are groping for it.

That is why we are sitting here at the center of one of the manufacturing companies of this wonderful metal. Wouldn't you say it could be called a "wonder metal"?

Mr. VANDENBURGH. Very unusual properties that everyone has been waiting for.

Senator MALONE. Then what we seem to be waiting for now, is waiting for two producers to solve the question. We have waited 3 years.

What would you do if you were sitting in Washington and could do something tomorrow? Would you call in what you consider capable companies who have established reputations in certain fields and try to interest them in producing the titanium?

Mr. VANDENBURGH. From the standpoint of the country, I believe that is what we should do. As has been brought out, we must recognize the possibility of a new method, but I firmly believe that by getting the quality of sponge to a good consistency, which I believe will come as time goes on and more tons of it are produced, even though the plants may be obsolete in 5 or 10 years—but my own opinion is that by getting the volume up, giving us an opportunity to rework scrap on a bigger scale, we may be making enough dollar savings in the price of the product we can sell to the aircraft company, to perhaps temper the loss that may come about by obsolescence.

That is one thing. I feel very strongly that there are probably several good chemical companies in this country who, with the proper contract, would want to get into this picture.

MORE COOPERATION NEEDED

I also would like to state that I feel quite strongly—and I know Mr. Roemer and our board of directors feel this way—that anything that we can do to help get this titanium industry going is going to benefit us in the long run. I would like to see a lot more cooperation all the way down the line. I feel that at the present time some of the manufacturers can do a good job, a job better than the next one.

Maybe we can do a portion better than the other person. Let's make sure that we are all in the right niche and if our method of remelting scrap is good, I think we would be willing to share that with the others who have the same type facility. I think we are looking at, let's say, jockying for position now, which is wrong.

This is going to be used by the military 95 percent probably for the next 10 years. With the terriffic expansion that I think is bound to come, I believe that in many cases we are foolish in trying to jockey for position now; whereas, if somehow we could pool efforts to arrive there sooner—it is going to be a big business and there is plenty for all, you might say—that I believe is a fair statement of our position, and I think we would all benefit.

Mr. ROEMER. If I may, Senator, I would like to reiterate what Mr. Vandenburg has said, and to say that is the company policy. That is exactly the way we feel. While there has been some things that Republic had helped in rolling which we couldn't roll, and REM-CRU has helped us on certain things, we feel that there could be a much closer working relationship on various technical problems or various specifications, whether those specifications are on raw products or what is the realistic specification for sponge that everybody can pitch in and do the best job they can.

We have been willing to be of help or service wherever we can. We have been perfectly willing to take a lot of sponge from any place we can get it to evaluate. We have furnished sample lots of material that we have rolled, and so forth, to people so they can evaluate them. I think that along the line there for a while we were almost giving away more raw titanium products than we were selling at one stage of the game.

One thing I would like to say, and that is that all the financial assistance up to date has been given to the sponge producers. I feel that maybe one of these days some of the smelters and fabricators of titanium, if this program is really pushed and should they need some extra special equipment for the handling and the process of titanium that could be obsolete just as quickly and easily as the sponge process, that it may be some of these producers one of these days might need some financial assistance and help on somewhat the same basis as has been given to the sponge producers, because it is just as important and necessary that we have the right melting techniques and all of the other equipment as it is to have good sponge-producing facilities.

Senator MALONE. I think what you say makes considerable sense. It is the responsibility of the Government needing this material, as they do, to encourage it.

Well, wouldn't you say then from your testimony the availability of the sponge or the lack of the sponge is the bottleneck?

Mr. ROEMER. Correct.

Senator MALONE. Wouldn't you say then that any effort that can be made now to increase the volume of sponge would be justified?

Mr. ROEMER. We feel that way.

Senator MALONE. And the field is wide open?

Mr. ROEMER. Yes.

Mr. VANDENBURGH. I agree with that. I would like to add that it is just as important that anything that can be done to start really re-using scrap, which is a quick source of additional titanium, should be done.

Senator MALONE. The testimony has shown that.

Mr. ROEMER. In other words, a few million dollars spent in that direction might go much further and quicker.

Senator MALONE. The Crane Co., of Chicago, has taken a contract for 15 tons, I believe, per day, or whatever it is. They looked around for quite awhile, and I understand they have tentatively agreed to settle in Tennessee. What was their particular need in this field? Wasn't it power they were looking for in addition to a proper site?

Mr. ROEMER. I believe that is right.

Senator MALONE. If that is true, power is a sort of bottleneck in the manufacture of titanium, the same as it might be in any other material that takes a large amount of power per pound kilowatt-hours.

So one of the bottlenecks, at least, in the manufacture of sponge is the availability of power at a proper price.

But the bottleneck right now in industry, as far as titanium is concerned, is not in the rolling, not in the feasibility of the manufacture, but it is in the availability of the sponge. Is that the way I understand both of you testify?

Mr. VANDENBURGH. Yes.

Mr. ROEMER. Yes.

Senator MALONE. Does that complete your statement?

Mr. ROEMER. I have no further statement.

Mr. VANDENBURGH. Nothing further.

Senator MALONE. If you think of anything that you think would help the committee, we would appreciate it if you would mail it to the chairman and send it to the Senate Office Building. It can be made part of your statement.

We thank you very much for your appearance.

Mr. ROEMER. We appreciate being here and hope that we have contributed to the hearing.

Senator MALONE. I want to call one more witness.

Fred Lohse is here representing the Kaiser Co., and he has a very short statement to make.

TESTIMONY OF FRED LOHSE, ASSISTANT TO THE VICE PRESIDENT AND DIRECTOR OF RESEARCH AND DEVELOPMENT, KAISER ALUMINUM & CHEMICAL CORP. OF OAKLAND, CALIF.

Mr. LOHSE. I am Fred Lohse, assistant to the vice president and director of research and development, Kaiser Aluminum & Chemical Corp., Oakland, Calif.

By way of introduction, Senator, in the interest of conducting our business soundly, we became interested in the possible inroads that titanium might make to the aluminum industry, in 1950.

At that time, as all of you know, the publicity and the promise of rapid progress in the development of the Kroll process attracted a lot of attention. During the study that we conducted, we ran across a slant in the field of the production of the sponge that we decided to follow, so in the interim we have spent 2 years doing research and have developed, we think, a potential process for making titanium metal.

Senator MALONE. Sponge?

Mr. LOHSE. Not sponge as such, but titanium metal at the sponge stage.

This spring we had a National Academy of Sciences committee headed by Jim Long, of Washington, D. C., and composed of Jim and K. K. Kelly, of the Bureau of Mines, and W. K. Davis of Cal Research & Development Corp., make a study of our process.

They have submitted a report to what was then the Defense Materials Procurement Agency which was headed at that time by Howard Mann.

That report is in the hands of that agency, or its successor.

During the last year, also concurrently with out research effort, we have been carrying on a considerable cooperative effort between our Metallurgical Research Laboratories in Trentwood, Wash., and Wright Field in the area that is generally supervised by General Metzger. We think General Metzger has served far beyond the call of duty in trying to get people into the production of sponge.

He knew of our research effort and has been very anxious that we do something further. I believe that we are no different than any other company who is spending its own money on research on new titanium processes. We feel that we are groping in the woods.

We haven't known at any time the real direction in which titanium production and fabricating was going, so we have stated our position as it stands today, in a letter to General Metzger. It is substantially that we think that whereas it has been agreed that we have the fundamental elements of the process, we should get some kind of encouragement, financial or at least as to the direction in which the industry is moving, before we go to the next stage, which will be a much larger undertaking.

Senator MALONE. Could you make a copy of this letter a part of the record of your testimony here?

Mr. LOHSE. We will send you a copy of the letter to General Metzger.

(The information referred to follows:)

KAISER ALUMINUM & CHEMICAL CORP.,
Washington 6, D. C., November 10, 1953.

Mr. JEROME S. ADLERMAN,
Senate Office Building, Washington 25, D. C.

DEAR MR. ADLERMAN: I have just been informed by our Mr. Fred Lohse, who is in the east on business matters, that his Oakland office has forwarded to him your letter of November 3, 1953, requesting copies of our correspondence on the subject of titanium production which Mr. Lohse mentioned in the recent hearings at Henderson, Nev.

Mr. Lohse has asked me to forward this correspondence to you and I am therefore enclosing copies of our letters from October 30, 1952, through October 14, 1953, which cover the subject.

If you desire any further information, Mr. Lohse will be in Washington on November 17 and 18 and will be available to give you any further data you require.

Very truly yours,

KAISER ALUMINUM & CHEMICAL CORP.,
By WARD C. HUMPHREYS,
Manager, Washington Office.

KAISER ALUMINUM & CHEMICAL CORP.,
Oakland 12, Calif., October 14, 1953.

GENERAL SERVICES ADMINISTRATION,
Materials Division, Washington 25, D. C.

GENTLEMEN: It is our understanding that your division has taken over from the Defense Materials Procurement Agency, Minor and Light Metals Branch, all matters pertaining to titanium which had previously been handled by that agency. We have discussed briefly with your division our previous correspondence and proposals submitted to Defense Materials Procurement Agency and it is our understanding that you now wish to further review this subject and possibly reopen negotiations.

For your information in confirming previous conversations, the following is very briefly the background of the subject. By our letter of March 4, 1953, we advised the Defense Materials Procurement Agency of certain research work which we have performed on a new process for the production of ductile titanium metal and of our willingness to cooperate with them should they desire to further develop the process.

Our letter of May 6, also to Defense Materials Procurement Agency, set forth in considerably more detail information concerning our process and proposed a pilot plant program of an estimated 18 months' duration with estimated cost of $667,000. At the instruction of that agency a 3-man team of scientists, under the sponsorship of the National Academy of Science, visited our laboratory for the purpose of evaluating the results of our research work and to report to them their recommendations regarding further exploitation of the process. By letter of July 16 from Defense Materials Procurement Agency they stated, "Careful consideration of your case has indicated that your process has not developed to a stage that would warrant Government support at this time."

It is our understanding from discussion with the scientific team at the time their investigation was made that it was their belief before a pilot program was inaugurated that certain additional and larger scale laboratory work should be performed. We take no exception to this opinion and point out that the type of laboratory work which we believe was referred to by the scientific team is included as a part of our proposed pilot program but in the essence of time has been meshed with the pilot equipment design and construction. Should it appear desirable to completely separate the larger scale laboratory work and the pilot work such can readily be done at some additional cost in money and time. We estimate that the additional laboratory scale work might be performed in a period of 16 months and at an estimated cost of approximately $220,000.

You inquired further into the corporation's reason for postponing further work on this project in the absence of Government participation. As stated in our previous correspondence, the decision to defer all further work, lacking Government participation, is entirely unrelated to the merit of the process. You have inquired for greater detail concerning the laboratory work which we have to date performed, and at your request our Dr. Byrns has today attended a meeting of your advisory board and has supplied them with pertinent information, which information is in greater detail than that contained in our letter of May 6. You asked that we elaborate further on the probable cost of metal produced by our process. At the present stage of development we consider it unwise to speculate on probable production costs other than to cite that our process has certain features which inherently will result in a metal production cost lower by a considerable margin than that which might be expected from other processes known to us.

You have suggested that we have a sample of our laboratory production analyzed by the laboratory at the Bureau of Mines, Boulder, Colo., and accordingly we are so doing.

We trust that the above information will justify your further consideration of our proposal of May 6.

Very truly yours,

R. E. KNIGHT, *Vice President.*

KAISER ALUMINUM & CHEMICAL CORP.,
Oakland 12, Calif., October 30, 1952.

Brig. Gen. K. D. METZGER,
USAF, Headquarters, Air Materiel Command,
Wright-Patterson Air Base, Ohio.

DEAR GENERAL METZGER: As we discussed with you recently, we have for some time been engaged in a research project aimed at the development of a continuous method for the reduction of titanium metal. On October 27 we discussed this subject with Mr. Roy Watkins of your staff and he has urged that we present the following for your consideration.

As outlined below, we have made substantial progress in the development of a new and improved process for the reduction of titanium metal. For various reasons, however, it may become necessary for us to shelve this project for an indefinite period. Mr. Watkins, however, has emphasized so forcibly the strategic importance of improved methods for the reduction of titanium that, if it is the judgment of the Defense Establishment that the process which we have thus far developed is sufficiently important to warrant early development and if funds are available for that work, we would feel remiss in our duty if we did not make available our present facilities and the necessary technical manpower.

Our work can best be summarized as follows: Based upon intensive experience with the carbothermic reduction of magnesium it was first expected that a technically sound and economically attractive process might be developed through improvement of the Kroll process using magnesium reduction of titanium tetrachloride. However, our preliminary program soon convinced us that it would be extremely difficult, if not impossible, to make satisfactory improvements in this process. The critical stage appears to be the separation of excess magnesium metal and magnesium chloride from the crude titanium; we have concluded that this step will for some years require batchwise, high-temperature, low-vacuum distillation with long cycle time and exceptionally high power consumption.

Our program was then reoriented with the objective of developing a new process, based on the reduction of titanium tetrachloride, which—

(*a*) Would not involve the high-temperature, high-vacuum distillation step but would operate at substantially atmospheric pressure;

(*b*) Could be operated on a continuous basis;

(*c*) Could be operated without exposure of the metal to oxygen or moisture until the metal was in condition for melting;

(*d*) Would require significantly less electric power;

(*e*) Would eventually lead to lower production costs than the Kroll process.

On a laboratory basis this has been achieved, and the essential steps of a new reduction process have been experimentally established. The metal obtained is in a form which should be more satisfactory for melting than that from the Kroll process. In addition, it is believed that most, if not all, of the necessary alloying constituents can be incorporated as part of the reduction process, thus leading to improved alloy uniformity and lower power consumption. Although, as with every new process, continued laboratory work leads to better development of the full potential of the process, the next step which must be taken is an expanded program including pilot plant construction and operation to prove up the process on a practical scale.

Our current thoughts are that this program would involve two stages, of which the first stage would stress—

(*a*) A preliminary program, semicontinuous in nature, with the objective of determining with certainty that there are no major difficulties which have not shown up in small-scale work and to obtain adequate design data for a larger, continuous pilot plant.

(*b*) An evaluation of the proper operating conditions, such as retention time and temperature, as applied to larger scale operation.

(*c*) An evaluation of the proper materials of construction for economical large-scale application.

Based upon normal industry practice, preliminary estimates indicate that this phase would cost approximately $200,000 based on a period of 1 year for construction and operation.

The second phase would be construction and operation of a pilot plant designed for essentially continuous operation. The purpose of this phase would be primarily to obtain the necessary design data for a commercial-scale plant. A period of approximately 1 year would be required. Costs are difficult to evaluate until the first phase has been partially completed but are currently believed to be in the range of $350,000 to $400,000.

Total cost for the program is thus estimated to be in the order of $600,000 with an elapsed time of approximately 2 years. In the essence of time, however, the program could, at additional cost, be materially shortened. It should further be pointed out that full-scale plant design would be begun some time in advance of the completion of the program in order to minimize the elapse of time between completion of the work and commercial production of metal.

We trust that the above offers you a reasonably clear picture of the present status of our titanium project, and should you wish further information or should you wish to consult with members of our organization, we shall be happy to serve you.

Very truly yours,

KAISER ALUMINUM & CHEMICAL CORP.,
D. A. RHOADES,
Vice President and General Manager.

Senator MALONE. You have not said very much about your process. Is it a batch or continuous method, or how does it line up in that connection?

Mr. LOHSE. It is essentially a continuous process. It doesn't have the inherent batch characteristics of the Kroll process. It probably is more continuous than an electrolytic process. The point being that you deposit the metal and you take some handling to consolidate it.

Senator MALONE. You feel you are at the point now where if you had a contract along the lines of Titanium Corp. or Du Pont, where obsolete equipment is somewhat compensated for, and the loan repaid in metal, or in general along the same line, that you would be ready to talk business?

Mr. LOHSE. No. We are at the stage where a pilot operation is necessary.

I might add that sitting here yesterday and today listening to the progress that has been made on the Kroll process to date, and considering that the first work was done by the Bureau about 11 years ago, it seems rather obvious that if there are other companies who have gone through a laboratory stage and are now ready for pilot operations, the next stage being semicommercial production, that that phase of it should be considered very seriously by all concerned, because it is seldom a short phase to go through.

The Kroll process, which appears to be simple, has been essentially a pilot operation for 10 years.

Senator MALONE. Then would you give the committee some idea of the status of your negotiations? In other words, if General Metzger referred you to the organization, or a Washington committee, what have you had from them? What is the status of the negotiations?

Mr. LOHSE. The then DMPA advised us on the basis of the report to them by the National Academy of Sciences Committee that more experimental work should be done.

Senator MALONE. Prior to the pilot plant?

Mr. LOHSE. Intermediate between laboratory and pilot plant, in which they are in no position to finance directly.

Senator MALONE. Do you have any further statement?

Mr. LOHSE. No, sir, I think not.

Senator MALONE. I think that is very good, Mr. Lohse, and we appreciate your appearance here.

Mr. LOHSE. Thank you, sir.

Senator MALONE. As I mentioned before, it is getting late. We have the Bureau of Mines here, and I would like to have Mr. Mastin and Mr. Lloyd come forward for just one question.

FURTHER TESTIMONY OF REX R. LLOYD AND M. G. MASTIN, BUREAU OF MINES, BOULDER CITY, COLO.

Senator MALONE. You have heard the discussion this morning about the possible uses of titanium metal in lieu of other metals, strategic metals.

You have heard columbium mentioned, cobalt and other metals. Do you have any personal knowledge of the new metal, titanium, replacing in part or in whole in case of emergency, or if it was necessary, these other metals?

Mr. LLOYD. Well, I might say that when the Bureau of Mines first started work on titanium it was, of course, with that idea, that they might use titanium to replace certain scarce and strategic metals. I wouldn't say that I personally have any firsthand knowledge of replacements that are being made, except those that have been mentioned this morning.

Senator MALONE. Name the metals that you think it could in an emergency replace in part or in whole.

Mr. LLOYD. Well, of course, if it replaces stainless steel in certain applications, that would replace nickel, chromium and certain alloying constituents like molybdenum, which goes into stainless steel, and also the columbium that has already been mentioned.

I don't know offhand that I could mention any others. Mr. Wartman might have some idea.

Senator MALONE. Mr. Wartman?

Mr. WARTMAN. I have nothing to add to what Mr. Lloyd has said.

Senator MALONE. What about cobalt?

Mr. LLOYD. Of course, one of the worries on cobalt alloys for high-temperature uses is the great scarcity of cobalt.

But I am under the impression that in general titanium is not utilized at the high-temperature range at which the high cobalt alloys are used, or at least only to a more limited extent.

Senator MALONE. The replacement would be limited?

Mr. LLOYD. It is being used in high-temperature applications, mostly in intermediate temperature range, and not so much high temperature where cobalt alloys are used.

Senator MALONE. Would you be in a position of getting more accurate information or should we get that from the Bureau in Washington?

Mr. LLOYD. Normally the work on alloys is being carried out at the College Park station, and I think you could get more accurate information from Washington, or from that station.

Senator MALONE. While you are here, you are familiar, of course, and have testified about the Du Pont contract.

Do you know anything about the process that the Crane Co. intends to use?

Mr. LLOYD. Crane Co., of course, has made quite a detailed study of the Bureau of Mines' operations and we have had some discussions with them.

We know they intend to utilize the Kroll process. Just what modifications, if any, they have in their plans haven't been disclosed to us.

Senator MALONE. You have no opinion as far as the process is concerned?

Mr. LLOYD. We have no opinion, except we know it is the Kroll process, with perhaps some modification.

Senator MALONE. That is all, unless you have something further to offer.

Mr. LLOYD. No.

Senator MALONE. We will now adjourn for lunch until 2:30.

(Whereupon a recess was taken until 2:30 p. m. of the same day.)

AFTER RECESS

Senator MALONE. The committee will be in order.

Is Mr. Arthur Newell of the Stauffer Chemical Co. here?

Mr. NEWELL. Yes, sir.

TESTIMONY OF ARTHUR NEWELL, WORKS MANAGER, STAUFFER CHEMICAL CO., HENDERSON, NEV.

Senator MALONE. Mr. Newell, will you identify yourself for the record?

Mr. NEWELL. My name is Arthur Newell, I am works manager for the Stauffer Chemical Co. of Nevada, at Henderson.

Senator MALONE. Mr. Newell, you have listened to the evidence presented before the committee, starting with General Metzger yesterday, and to the statement of the objectives of the committee which are to determine the availability of the strategic and critical minerals, materials, and fuels to the United States in wartime.

"Strategic and critical" are only relative terms. If we need them a little worse they call it "strategic," and if we don't need it quite so much, or if you don't produce what you need, they call it "critical."

There are 77 of these critical and strategic materials. They vary in number from time to time, as of course you know. We are here particularly on the production of titanium, its present production, the future production, and the need for the metal. We are interested in the possible expansion of the industry in this area, and what the bottlenecks are and what can be done to alleviate that condition.

Your company produces certain materials that are used in the manufacture of titanium. Power seems to be one of the road blocks. I don't know yet just how serious that is. Naturally, the larger their production, the larger your production, and the more power you need, so if you could give us a general picture of your setup in that connection for the benefit of the committee, we would appreciate it.

Mr. NEWELL. We are adjacent to the area and the plant of the Titanium Co. We do supply to them several materials which go to

make up the raw materials upon which they work. The materials which we supply them are mainly chlorine, caustic soda, and hydrochloric acid.

STAUFFER PROBLEMS

At the present time our problems would fall in two categories, or at least the expansion of the titanium industry at this plant would consist of two things.

One of them, of course, is to supply the chlorine capacity, the amount of chlorine they would require to move into a greater production. In order to do that we must also take into account the power situation.

Insofar as the plant capacity is concerned, we are probably in good condition to take care of the production capacity. In other words, we have here in the plant six circuits for the production of chlorine.

At the present time only four of them are activated. We could put a fifth circuit on in approximately 90 days. We could put a sixth circuit on, which is the limit of our capacity without going into an extremely large amount of money, in approximately 9 months.

We are now producing with three circuits some 40,000 tons of chlorine annually, and we are also running the fourth circuit, which has a capacity of 13,000 tons, which makes our present capacity some 53,000 tons of chlorine annually.

If we put on the fifth circuit, that will make available another 13,000 tons annually.

If we put on the sixth and last circuit, that would make another 13,000 tons, or a total capacity of some 79,000 tons of chlorine per year.

Looking at it from the power standpoint, we have a contract with the Colorado River Commission for firm power in the amount of only 139 million kilowatt-hours annually; that is about 19,800 kilowatt capacity based on an 80 percent annual load factor.

At the present time, and for some time now, we have been running anything above three circuits on borrowed power, or power that is available here at the plant because somebody else who has it is not using it.

Senator MALONE. I think it was testified to this morning by Mr. Rollin Smith, manager of the Titanium Corp., that they have 41 million hours of Hoover Dam power unused.

Would that be part of the power that you are getting?

Mr. NEWELL. I couldn't say just where it comes from.

Senator MALONE. But it is unused power?

Mr. NEWELL. Yes; both Titanium and I think Pioche Manganese and Western Electric Chemical Cos., have some unused power, and we are drawing from the Colorado River Commission without any means of identifying just where it came from.

That means we need 44 million kilowatt-hours annually to run our fourth circuit. That means we need another 44 million for our fifth, and the same for our sixth.

Did Mr. Martindale come here? I would like for him to testify on the power. I could say this much, up to this time on the power situation: Mr. Martindale has been acting as power consultant for the Stauffer Chemical Co., and has spent a great deal of time in trying to uncover additional sources of power.

He has done considerable work in Arizona, and some in California. Through the Colorado River Commission we have set up a possible

source of power for these additional circuits. The Colorado River Commission has arranged a contract with the Arizona Power Authority to take off-peak power in the winter months.

That is on an if, as, and when proposition, as you know. Mr. Martindale is also working on the California end of it now, and there is a possibility that because of the difference in the time of year when the peaks occur in California and in Arizona, that this thing can be dovetailed in together so that we will be getting Arizona off-peak power in the winter and California off-peak power in the summer, which will create a condition where we would have almost a firm power.

Senator MALONE. Would this be a firm contract for secondary power, or would it be a contract for a kind of power that they could withdraw altogether or diminish in quantity at any time?

Mr. NEWELL. As I understand it, the power coming from Arizona is generated in two ways; that is, from the Hoover-Davis Dams, and also from a number of steam plants over there. The Arizona people are anxious to utilize their steam plants the full year round. They are willing to supply us, and apparently able to do it on a pretty regular basis during the winter months.

It is not what you call firm power; you couldn't tie yourself up to it exactly.

Senator MALONE. Is it firm power in any sense of the word? Do they guarantee in the winter months to give you a certain amount of power undiminished, or is it simply an if, as, and when?

Mr. NEWELL. It is an if, as, and when proposition.

Senator MALONE. All the way around?

Mr. NEWELL. Yes; with a reasonable assumption that you are going to get fairly steady power from them in the wintertime.

Senator MALONE. What has been the record of the power use over the last 20 years? Hasn't it been the record that no one has ever estimated the quantity actually used high enough in any one of the areas?

Mr. NEWELL. Well, I wouldn't have that information, Senator, but the growth curves indicate a rather regular rate in a lot of communities, but in a community or area like this, it goes up by leaps and bounds where you are developing a new industry.

Senator MALONE. I can't recall the figures, but in 1927 when I got into this Boulder Dam fight—now Hoover Dam—of course, there was nothing on the river then, and charts were made estimating the power use or growth of power in southern California, and none of the estimates ever approached what the use actually turned out to be.

Mr. NEWELL. Yes.

Senator MALONE. When I demanded a third of the power for the use of Nevada, we finally secured 36 percent for the two States. You could let it go when you didn't need it under certain conditions, and you could secure it again without prejudice when you did need it. This had never been done any place in the world.

I did make an estimate that we might use in 20 or 25 years—I would have to refer to the chart now, and I don't have it with me—187,000 horsepower, but no one believed it but me. I must admit that I was of an optimistic nature.

When you estimate the amount of power that they will use in Arizona, or that you will use here, and with the titanium industry and the chlorine and caustic soda and hydrochloric acid that is neces-

sary to go into this product, and you base that on a promise that isn't even a promise when you tie it down, it seems rather far afield. It looks good now until you start using power.

Mr. NEWELL. That is probably correct. However, in the history of Arizona, and also in California, they have been looking forward—considerably ahead—and they have been building steam plants to meet their peak loads.

The probability, I would guess, is that they would keep that up and if they do, you are going to have a certain amount of this peak power continuously up to some point. What point that is, I don't know.

POWER COSTS

Senator MALONE. What is the cost of this power?

Mr. NEWELL. It has been reported to us that the power coming from Arizona will be right around 6 mills delivered here, maybe six and a fraction.

Senator MALONE. This secondary power?

Mr. NEWELL. That is right.

Senator MALONE. How long a contract for 6 mills can you get?

Mr. NEWELL. I believe the contract with the Colorado River Commission is for 10 years.

Senator MALONE. Will they guarantee the price will not advance in 10 years?

Mr. NEWELL. I couldn't say for sure whether that is tied down to that figure or not. I would say probably it will advance. It will probably advance with the increase of cost of natural gas over there in that area, which they use for fuel.

Senator MALONE. That would be a logical contract if you have an if and when contract, that there would be no guaranty of price; it would depend on the price of fuel, wages, and other considerations.

Mr. NEWELL. That is right.

Senator MALONE. The difference in hydro and steam or diesel is, of course, that once the expenditure is made the hydro installation costs more, but once it is made there is no variation in price in an inflationary period, such as we are still under, with the exception of the labor and the replacements which are relatively small as to the overall cost. Whereas, steam or diesel power is always subject to a fuel price. There is no place for it to go but up.

So you might compare it to hydroelectric costs now, and the steam power which might be cheaper. There is no assurance as to that. As a matter of fact, all experience points that there is assurance that it doesn't take very long until the steam power increases in price and catches up with any hydroelectric power offered.

Mr. NEWELL. It seems to us that the program as set up is a rather logical one in most respects, inasmuch as possibly for the next 5 to 8 years we can expect to get a certain amount of offpeak power from Arizona and California, with the idea that eventually there will be another dam built above here which will increase the power.

I don't know how far that has gone; you probably know more about that.

Senator MALONE. I have a bill introduced to build Bridge Canyon. The history of those things is rather uncertain. It took a good many years to pass a bill for Boulder Dam—now Hoover Dam—and of course, about 5 years to build it. I don't know how long it will take

us to provide for the construction of Bridge Canyon. I am sure we will do it. That will take about 4 or 5 years to build.

Mr. NEWELL. The other alternatives we have for power——

Senator MALONE. I might say at this point that it is estimated there will be approximately 800,000 kilowatts of power generated at Bridge Canyon, which is about the same amount, approximately, that we have here at Hoover Dam altogether.

Mr. NEWELL. The other alternatives that we have, of course, is a positive step of going ahead and putting in a steam plant of our own in this area here, either by the Stauffer Co. or jointly with other companies.

The other one is, of course, of very considerable interest, and that is Sierra power, or rather, Shasta power. It is a matter of dollars and cents on all of these things, and that will dictate what action is finally taken.

Senator MALONE. What has been done toward estimating the cost of steam power?

Mr. NEWELL. The Basic Management, Inc.—let me take that back. The Colorado River Commission has, in its investigation of power sources, had contacts from at least two large concerns who build powerplants in the West. I believe they have furnished the Colorado River Commission with prices on the plants themselves, and the probable cost of power coming from these plants.

Senator MALONE. Is there some expectancy that natural gas will reach this area?

Mr. NEWELL. Yes, sir. It is rather positive now that natural gas will reach us some time early in 1954, if not at the end of 1953.

However, we are not assured definitely at this time whether there will be enough in that original line to take care of a large powerplant. We might need a booster on the line, or an additional line to do it.

Senator MALONE. What other fuel is contemplated?

Mr. NEWELL. Of course, the other fuel which would be more competitive, more closely competitive with gas, would be coal.

Senator MALONE. Coal from Utah?

Mr. NEWELL. I would imagine so; that seems to be the closest source.

Senator MALONE. Has there been any investigation of the possibility of utilizing Shasta Dam power in this area?

Mr. NEWELL. I believe so; I think the Colorado River Commission has investigated that. I think Mr. Martindale has looked at that picture in some detail, which I would like to have him tell you about it.

I would like to have him discuss the whole power situation because he is more familiar with it and more able to do it than I am.

Senator MALONE. You may proceed with your statement.

Mr. NEWELL. That covers pretty much what I have to say here, unless you have some specific questions you would like to ask.

I would like to give you a copy of this for the record, if you care for it.

Senator MALONE. That has to do with the power requirement?

Mr. NEWELL. Yes, sir.

Senator MALONE. Stauffer Chemical Co. of Nevada, dated September 23, 1953, entitled "Power Data" will be accepted as a part of Mr. Newell's testimony, and a part of the record at this point:

Power Data

	Kilowatt-hours
Power year, June 1951–May 1952, inclusive:	
Firm contract with Colorado River Commission (annual)	139,000,000
Actual use	212,485,179
Usage exceeded contract by	73,485,179
Power year, June 1952–May 1953, inclusive:	
Firm contract with Colorado River Commission (annual)	139,000,000
Actual use	161,491,000
Usage exceeded contract by	22,491,000
Power year, June 1953–May 1954:	
Usage June 1953–August 1953, 1st quarter	43,507,832
Equivalent to kilowatt-hours annually	174,151,328
Estimated usage will exceed contract by	35,151,328
Power required to operate:	
4 circuits annually over and above Colorado River Commission contract	44,000,000
5 circuits annually over and above Colorado River Commission contract [1]	88,000,000
6 circuits annually over and above Colorado River Commission contract [2]	132,000,000

[1] Probable 1954–55 power year.
[2] Possible 1955–56 power year.

Power data—Estimated overall Stauffer power requirements

Power year	Kilowatt-hours	Capacity kilowatts at 80 percent annual load factor
1953–54	174,000,000	24,800
1954–55	227,000,000	32,300
1955–56	271,000,000	38,700
1956–57 on	Same as 1955–56	

Senator MALONE. You would anticipate no hindrance of producing all of the chlorine, caustic soda and hydrochloric acid that would be needed here, not only with the 10-ton-per-day titanium metal plant, but an additional 15 tons per day which has been discussed?

Mr. NEWELL. I would think we would have no difficulty in meeting the program as it appears at this time.

I think we have ample capacity to do it. We have recently put in some additional hydrochloric capacity, as you know. Our present hydrochloric acid supply is a byproduct from the manufacture of DDT. We have recently installed chlorine-hydrogen burning equipment, with which we could make another additional 50 or more tons of hydrochloric acid a day.

Senator MALONE. Could you give us some idea of the amount of chlorine, caustic soda, and hydrochloric acid in units that would be necessary for the full 10-ton-per-day capacity so there would be some criterion as to what might be used in the future.

Mr. NEWELL. I am not able to do that because I am not familiar with the tonnage and with the operations of the Titanium Metals Corp. I think Mr. Smith would be more able to do that than I.

Senator MALONE. Would Mr. Martindale know?

Mr. NEWELL. No, sir.

Senator MALONE. Could you furnish that information for the committee?

Mr. NEWELL. If Mr. Smith is agreeable.

Senator MALONE. If it is considered in any way a secret between the companies, why, I would not demand it at this time.

Mr. NEWELL. Of course, you can figure these things out theoretically. On a theoretical basis it takes about 3 pounds of chlorine to produce 1 pound of titanium metals. How he utilizes that chlorine is his business.

Senator MALONE. Of course I did not mean the complete utilization process.

Mr. NEWELL. We would have one consumption figure under the set of conditions where he doesn't recover the chlorine from the magnesium chloride and we would have another one where he does do that.

Senator MALONE. How about the caustic soda?

Mr. NEWELL. Caustic soda, I believe, they use that in an auxiliary process. I don't think it is a critical matter. It probably would be reduced as they go along.

Senator MALONE. Hydrochloric acid?

Mr. NEWELL. I don't know what the process is. I understand from the Bureau of Mines it is used as a leaching.

Senator MALONE. What quantity do they use?

Mr. NEWELL. They use about a third of our production at the present time.

Senator MALONE. What is your production?

Mr. NEWELL. Roughly around 2,000 tons a month.

Senator MALONE. Do you also furnish the product discussed here before, titanium tetrachloride for the Bureau of Mines?

Mr. NEWELL. Titanium tetrachloride, not from this plant. The Niagara Falls plant of Stauffer does.

Senator MALONE. And that is shipped in?

Mr. NEWELL. Yes.

Senator MALONE. You are not prepared to furnish this material?

Mr. NEWELL. No, sir; we have no equipment whatsoever here. They had a very small plant at Niagara Falls, and the demand for titanium tetrachloride has been rather spotty.

At times the Bureau of Mines took some, and at times they were shut down entirely. At the present time I understand that Niagara Falls is furnishing the Bureau of Mines a car or two a month of this material.

Senator MALONE. You would rather leave the power discussion for Mr. Martindale?

Mr. NEWELL. Yes, if you please.

Senator MALONE. I think, Mr. Newell, if that completes your statement we will excuse you now.

If anything occurs to you that you think would be interesting to the committee, or helpful to the committee, knowing the objectives of the committee, will you just write the chairman a letter and send it to the Senate Office Building.

Mr. NEWELL. Thank you very much. I would like to say one more thing.

As titanium grows more plentiful and cheaper in price, I think there is a possibility, especially in wartime and possibly in peace-

time too, that it might replace a number of the materials, or a number of the metals like nickel, monel metal, and so forth, which we use in our equipment in the caustic plant because of the very corrosive conditions we have there.

Those pieces of equipment are very expensive to maintain and they cost a great deal of money when they are new and they don't last too long. If we are able to develop a new metal which will stand up better, those things will very materially reduce our cost of operation.

Senator MALONE. Titanium, as has been testified, is gaining a reputation as the least corrosive of any metal at the present time.

Mr. NEWELL. That is right; it is very resistant to brine and chlorine, and things like that.

Senator MALONE. Almost impervious.

Mr. NEWELL. That is right.

Senator MALONE. Thank you, Mr. Newell.

(Witness excused.)

Senator MALONE. Is Mr. McCarroll here?

TESTIMONY OF SIDNEY J. McCARROLL, GENERAL SUPERINTENDENT, MANGANESE, INC., HENDERSON, NEV.

Senator MALONE. Will you identify yourself, Mr. McCarroll, for the record?

Mr. MCCARROLL. Sidney McCarroll, general superintendent of Manganese, Inc., Henderson, Nev.

Senator MALONE. You are generally familiar with the objectives of the committee to determine the availability of the strategic and critical minerals, fuels, and materials to the Nation in wartime. Manganese is one of these materials.

Have you any general statement you would like to make relative to the availability of the material, and to any bottlenecks that may have occurred in your production?

Mr. MCCARROLL. Well, we are operating the plant here at Henderson known as the Three Kids, and are employing a flotation process, which is more or less new in the field of manganese beneficiation.

Our research work has been under way since about 1951 and continues at the present time. We have had a great deal of help from the Bureau of Mines, and we exchange information rather freely with them as to anything that we find. Of course, they give us the benefit of all of their discoveries.

Senator MALONE. Are they working actively in this search in that connection at the present time?

Mr. MCCARROLL. I understand they are, not directly on our ore, but on ores of similar nature.

Senator MALONE. What is the nature of your ore here?

That is, as to grade and characteristics?

Mr. MCCARROLL. Well, our ores are oxide ores, and that is the principle ore of manganese that is found here in the southwest, with the exception of the deposits like Pioche, which is principally a carbonated ore.

Senator MALONE. Do you ship any of the ore from Pioche here?

Mr. MCCARROLL. No; our production is entirely from the Three Kids mine.

Senator MALONE. What generally does your grade run there in the Three Kids deposit?

Mr. MCCARROLL. Well, we have been treating ore that will probably average a little over 24 percent, but our aim is to average the ore to 18 percent. Our operations, which at present are shut down, will continue on 18 percent, or will when we resume operations.

Senator MALONE. That is, you could run on 24 percent, but you use enough low grade to average about 18 percent?

Mr. MCCARROLL. It isn't just a question of mixing the ore. In the manganese deposits by selective mining, you might say, you could separate ore which would be of higher grade, but a more economic way of doing it is to mine the ore all together and get a little bit lower grade ore.

Senator MALONE. This means you take it as it comes.

Mr. MCCARROLL. We take it more or less as it comes.

Senator MALONE. What about the 24 percent? If you were selective you would get 24 percent?

Mr. MCCARROLL. Yes. That was mined a little bit more selectively than we expect to continue in our operations.

Senator MALONE. What is the estimate of the total tonnage in this deposit at the present time?

Mr. MCCARROLL. There have been several estimates which would vary from 2½ to 3 million tons.

Senator MALONE. Running about 18 percent?

Mr. MCCARROLL. Running about 18 percent. The cut-off point has been figured as low as 14 percent if we ran something over 3 million tons. If we held it to 2¾ million, we would be at 18 percent.

Senator MALONE. What is your rate of production now, or what has it been and what will it be be when you reach your objective?

Mr. MCCARROLL. Well, at the present time we don't have any production. We have had a disastrous fire and the main part of the plant was burned down. We are now rebuilding that part of the plant.

We do expect to have part of the plant in operation on the 15th of November, and at that time we will finish processing approximately 700,000 units of manganese, which we have in storage.

Senator MALONE. Describe a unit.

Mr. MCCARROLL. A unit of manganese is 22.4 pounds; it is a long-ton unit.

Senator MALONE. Of pure manganese?

Mr. MCCARROLL. Of metallic manganese.

Senator MALONE. Of what purity?

Mr. MCCARROLL. That would be pure manganese.

Senator MALONE. What would be your rate of production monthly or annually if you were in full production? What are your aims in that connection?

Mr. MCCARROLL. Our aim is to treat 1,200 long tons of ore per day. At the time the plant was designed, it was designed for 1,200 long tons.

Senator MALONE. That is per day?

Mr. MCCARROLL. That is right.

Senator MALONE. 1,200 long tons.

Mr. MCCARROLL. However, we ran into difficulties, like most new plants, and we found out that parts of the plant weren't big enough and we never got up to a production of over 800 tons a day.

We were struck by a minor disaster in the first part of this year when our kiln broke in two and we had to suspend operations for about 3 months.

Shortly after we resumed operations the fire burned our plant down. We are redesigning the plant to also treat 1,200 long tons a day, and are making some improvements and additions that we found were necessary. In those additions and changes the power has gone up quite a bit over our original estimate.

Senator MALONE. Your power requirements?

Mr. CARROLL. Our power requirements will be approximately 50 percent over our original estimate. This condition is due almost entirely to one stage in our process that is known as conditioning and we are doing work on this at the present time.

The Bureau of Mines is also doing work on that particular phase, and if the key to it can be found, why then, our power requirements will be dropped considerably.

Senator MALONE. What are your power requirements expressed in units or however it is commonly expressed?

Mr. MCCARROLL. Well, we will be using now at the rate of approximately 21 million kilowatts a year.

Senator MALONE. Kilowatt-hours?

Mr. MCCARROLL. Yes. We have put in a request to the Colorado River Commission for 25 million.

Senator MALONE. A total of 25 million?

Mr. MCCARROLL. Twenty-five million total.

Senator MALONE. That will be a 4 million more additional hours.

Mr. MCCARROLL. That is right; that will be for the necessary power to mine underground when we come to that stage, which will probably be within the next 2 or 3 years.

Senator MALONE. You are surface mining now?

Mr. MCCARROLL. Our present mining is open-cut mining.

Senator MALONE. And this would be your full production, this 21 million kilowatt-hours would take care of your full production of 1,200 long tons per day.

Mr. MCCARROLL. Yes. That is the ore, the raw ore, you see. Of that we will probably produce somewhere between 400 and 450 tons of nodulized manganese.

Senator MALONE. Go ahead and describe your operation any way you see fit.

As I understand it, your maximum demand for power would be the 25 million kilowatt-hours.

Mr. MCCARROLL. That is right.

Senator MALONE. Per year?

Mr. MCCARROLL. That is right.

Senator MALONE. What does that amount to in kilowatts?

Mr. MCCARROLL. That would be about 4,600 kilowatts, and would be figured on the 300-day year, approximately.

Senator MALONE. Do you have any difficulty securing the amount of power you need?

Mr. MCCARROLL. Well, we have 6 million kilowatts of firm power.

Senator MALONE. Out of the 21 million?

Mr. MCCARROLL. Yes.

Senator MALONE. The rest of it is secondary?

Mr. McCARROLL. Yes.

Senator MALONE. How secondary is it?

Mr. McCARROLL. Well, it is pretty well mixed up, I would say.

Senator MALONE. What part of the percentage of the time do you estimate that you would get your secondary power? Will you describe that for the committee?

Mr. McCARROLL. The secondary power is offpeak power, which is from the coast towns of Glendale and Burbank and Los Angeles.

I believe there is some of the power coming from Davis. I believe there is some arrangement made for Davis power.

Senator MALONE. How much of it would come from local sources, and how much from southern California?

Mr. McCARROLL. I couldn't give you the percentage of that.

Senator MALONE. Could you secure that for the committee and send it to the chairman at the Senate Office Building?

Mr. McCARROLL. Yes.

Senator MALONE. The reason for that inquiry, if you are getting southern California power, is that power that has been allocated to the southern California cities from Hoover Dam and we will get it until they get ready to use it.

Mr. McCARROLL. As far as I know.

Senator MALONE. Do you know what it is?

Mr. McCARROLL. Do I know?

Senator MALONE. Are you sure what it is.

Mr. McCARROLL. I believe that is the power that has been apportioned to these towns, and it is my understanding now that to make that a little more certain, the installation of another unit will assure the delivery of that power at times when the other generators are ordinarily loaded.

Senator MALONE. You are talking about the No. 8 generator?

Mr. McCARROLL. Yes.

Senator MALONE. Isn't there some argument now as to who is going to control No. 8 generator, whether it will be California or Nevada?

Mr. McCARROLL. Well, there may be.

Senator MALONE. I hope there is, from what I have heard.

I still would like to know whether the power from southern California cities is power that they may secure elsewhere and call it secondary, and you would get it if as and when.

Is that the way you get it?

Mr. McCARROLL. Yes.

Senator MALONE. Or whether it is Hoover Dam power or Davis Dam power that is allocated to the southern California cities, or Bureau power and you get it when they take up the slack.

Mr. McCARROLL. Well, that point is not clear to me, Senator.

Senator MALONE. Will you try to clarify that in your letter to the chairman?

Mr. McCARROLL. Yes, sir.

(The letter referred to follows:)

MANGANESE, INC.,
Henderson, Nev., November 13, 1953.

JEROME S. ADLERMAN,
Counsel, Minerals, Materials, and Fuels Economic Subcommittee,
United States Senate Office Building, Washington, D. C.

DEAR MR. ADLERMAN: Your letter of November 3 to Mr. Sidney J. McCarroll, general superintendent, requesting statement of amount of power required for

our operations from local sources and from southern California has been received. On October 1 Mr. McCarroll wrote to Senator George A. Malone as follows:

"The following information is submitted to supplement my testimony given to your committee during the hearings held at Henderson, Nev., on September 28 and 29, 1953. The first unanswered question was: 'What is the percentage of off-peak power consumed by Manganese, Inc., that is being supplied by California cities of the Los Angeles area?'

"Actually we do not receive any power from their off-peak supply. Our off-peak power is supplied from the Arizona allotment of Hoover and Davis Dams power. Under normal conditions this power which is not 'firm' amounts to 65 percent of our consumption. If our anticipated power requirements for 1955 and in the future are met, the percentage would be raised to 80 percent of our total consumption.

'The actual point of supply in every case would be Hoover or Davis Dams, and the energy is delivered exchange power. The charges, however, are figured on the basis of transmitting power from generating facilities in Arizona or in the Los Angeles area, if a firm agreement could be reached with the California communities.

"In other words, while all of the power supplied to us comes from Hoover and Davis Dams, we pay secondary power rates on 65 percent, due to commitments of these projects to the various agencies.

"I trust that this information will complete my testimony and wish to thank you again for the opportunity of presenting our views on this matter."

Very truly yours,

F. A. McGONIGLE,
General Manager.

Senator MALONE. You can probably find out from the Colorado River Commission. We will see if we can clear it up when they come before us here.

How long will your operation be, according to your estimates and looking ahead over the years?

Mr. MCCARROLL. The life of our operation is expected to be somewhere between 8 and 10 years unless there are developments which would allow us to treat lower grade ore than we are now able to treat.

Senator MALONE. And you might get down to your 14-percent ore instead of 18 percent?

Mr. MCCARROLL. That is right. However, when I say 8 to 10 years, there is some more reason for saying that.

We have two Government contracts for the production of manganese. One is for the upgrading of approximately 5½ million units of manganese, which is the property of the Government now.

Senator MALONE. They have contracted for 5½ million units?

Mr. MCCARROLL. They own 5½ million units which we have contracted——

Senator MALONE. To deliver?

Mr. MCCARROLL. To upgrade and deliver to them.

Senator MALONE. What do you mean "upgrade for them." You are doing it outright here?

Mr. MCCARROLL. It is their ore which has been mined, but it is not of the metallurgical grade ore that can be used in any process.

Senator MALONE. Well, it is Three Kids ore?

Mr. MCCARROLL. Three Kids ore mined at the time the property was under the Government administration.

Senator MALONE. During World War II?

Mr. MCCARROLL. Yes.

Senator MALONE. And it is just there in a pile?

Mr. McCarroll. It is there in a pile and is the property of the Government.

Senator Malone. What does that run?

Mr. McCarroll. That will run about 20 percent. I believe that we are required to make 90 percent recovery of it.

Senator Malone. Are you working on that?

Mr. McCarroll. We have treated part of it, yes; a small part of it.

Senator Malone. But at the present moment you are replacing your mill, and there is no operation at all?

Mr. McCarroll. That is right.

Senator Malone. And you say you will be in operation at about what time?

Mr. McCarroll. In the middle of November we will be in partial operation. We will start delivering nodules from concentrates that we now have on hand.

Senator Malone. I guess you have already stated for the record when you presumed you will reach full operation, but just what date would that be?

Mr. McCarroll. We expect to reach full operation about the end of January. Our new plant will be in production in the middle of January.

Senator Malone. What generally is this process called that you are using?

Mr. McCarroll. We are using a combination of processes. I think the correct term would be "upgrading of manganese."

Senator Malone. Is it a chemical process or concentration process?

Mr. McCarroll. It is a flotation process, which is a mineral dressing process, and then the concentrates are finished by a pyrometallurgical process.

Senator Malone. Do you have any further statement?

Mr. McCarroll. I don't believe I do. I would like to make a matter of record again the cooperation we have had from the Bureau of Mines.

Senator Malone. And you do exchange information?

Mr. McCarroll. Yes; we have an open plant. We exchange information with everybody. We find that by giving out information we generally get more than what we give out, and we give out whatever we have.

Senator Malone. That is a very good spirit. Thank you very much, Mr. McCarroll.

(Witness excused.)

Senator Malone. Is R. W. Lottridge present?

Mr. Lottridge. Yes, sir.

TESTIMONY OF R. W. LOTTRIDGE, MANAGER, PIOCHE MANGANESE CO., HENDERSON, NEV.

Senator Malone. Will you identify yourself for the record and proceed in your own way with any statement you would like to make for the benefit of the committee.

Mr. Lottridge. My name is R. W. Lottridge. I am the manager of the Pioche Manganese Co. smelter at Henderson.

Where would you like me to start, Senator, with specific regard to our operation here?

Senator MALONE. I think you have listened to the testimony of the objectives of the committee.

Will you proceed in your own way and give us the information that you think will be helpful.

Mr. LOTTRIDGE. Well, our smelter is located at Henderson for the purpose of processing manganese ores and nodules for the manufacture of ferromanganese; ferromanganese is an alloy of manganese and iron, which is essential to the manufacture of steel.

There is about 15 pounds, roughly, of metallic manganese used in the manufacture of every ton of steel.

Senator MALONE. It used to be estimated at around 12 to 14 pounds; has it increased slightly?

Mr. LOTTRIDGE. Well, that figure is a variable figure. I find it variously estimated.

At the present time I find those figures in the trade publication. We are securing our ores principally from our parent company, which is the Combined Metals Reduction Co., from their operations at Castleton, where the ore is mined, beneficiated by flotation and nodulized in our own kiln plant, the Pioche Manganese Co. kiln plant at Pioche.

These nodules are shipped by rail to Henderson, combined with other ores and nodules and fed to electric furnaces. At the present time we have one furnace in operation.

Senator MALONE. Here in Henderson?

FIRM POWER

Mr. LOTTRIDGE. Yes. Our ultimate plan is to have 2 at the present moment, 2 stove furnaces in operatoin which will consume electric power at the rate of about 100 to 110 million kilowatt-hours per year, at a rate of delivery of about 15,000 kilowatts.

At the present time we have under firm contract with the Colorado River Commission about 75—well, not about, we have exactly 75,500,000 kilowatt-hours.

Senator MALONE. Under contract?

Mr. LOTTRIDGE. Under firm contract.

Senator MALONE. Is that firm power?

Mr. LOTTRIDGE. That is firm power under a contract rate of delivery of 10,200 kilowatts.

I would like to call attention to the committee that of that amount 17,500,000 are from the Lincoln County Power District and may be recalled by them if it were necessary for it to be used there.

Senator MALONE. How much was that?

Mr. LOTTRIDGE. 17,500,000, which leaves exactly 58 million under firm contract out of the Hoover-Davis pool.

We have requested the Colorado River Commission for an additional 35 million kilowatt-hours; the contract rate of delivery is 5,000 kilowatts, and under the arrangements which the Colorado River Commission has made for offbeat power with the State of Arizona through the Arizona Power Authority, we have reasonable assurance that it will be available to us.

Senator MALONE. Well, I have heard a good deal of this Arizona Power. Is it actually under contract to the Colorado River Commission, the Arizona Power?

Mr. LOTTRIDGE. For offpeak power, Senator.

Senator MALONE. They have it on contract?

Mr. LOTTRIDGE. For offpeak power which is available during the winter months.

Senator MALONE. Along the lines outlined by Mr. Rollin Smith, variable quantities?

Mr. LOTTRIDGE. That is correct; it is available, generally speaking, from the months of October through March of any year.

Senator MALONE. In variable quantities?

Mr. LOTTRIDGE. Yes.

Senator MALONE. And if they want to use it themselves for any reason, or for any reasons, there is no penalty on the Arizona people.

Mr. LOTTRIDGE. That is correct; although there is firm power available in Arizona to be obtained, but at a different price, of course.

Senator MALONE. What is the price of this power?

Mr. LOTTRIDGE. We don't know for sure. I imagine about 6 mills, probably, delivered.

Senator MALONE. Is this hydro power that comes from there?

Mr. LOTTRIDGE. No; that is steam-plant power.

Senator MALONE. What do they use for fuel?

Mr. LOTTRIDGE. They use natural gas mostly.

Senator MALONE. You are satisfied with the setup?

Mr. LOTTRIDGE. Well, yes. That meets our needs for the present time. Of course, we have plans in the future, some distance in the future.

Senator MALONE. How far?

Mr. LOTTRIDGE. It depends on so many factors that I can't be very definite, but we might want to expand—I mean economic factors—we might want to expand our manganese program; we might not want to expand in some other mineral, in which case I could see that in the course of 5 or 6 years we might well double our power requirements once and a half to two times our power requirements.

Senator MALONE. You have mentioned the production time element on the Three Kids down to certain grades. What about the Pioche area supply of manganese that is there at the present time, or that is anticipated will be developed with regular mining operations?

Mr. LOTTRIDGE. I think I will have to qualify that statement, Senator. Our ores at Pioche, Combined Metals Production Co.'s ores, are not pure manganese ores. They are associated with lead and zinc, and as you well know, what is an ore reserve today may not be an ore reserve tomorrow, or vice versa, depending upon the price of minerals.

The reduction of lead zinc prices, for instance, has had quite an effect in reducing the available amount of manganese. However, let me say this. Our ore reserves are sufficiently high so that we have had no concern about a continued operation. These manganese resources were developed during the development of the lead-zinc mining.

In other words, on the marginal lead-zinc ores in drilling and other methods of development, we have uncovered a considerable amount of manganese.

Senator MALONE. These ores in the Pioche district are what is generally known as "complex ores," is that right?

Mr. LOTTRIDGE. That is right.

Senator MALONE. Isn't this the same district that Ed Snider put in several years trying to whip the concentration and separation of lead zinc in the first instance?

Mr. LOTTRIDGE. That is exactly the district.

Senator MALONE. Twenty-five years ago.

Mr. LOTTRIDGE. Some of the refinements in selective flotation, or many of them, were developed in the beneficiating of these ores.

Senator MALONE. Of the complex ores of that district.

Mr. LOTTRIDGE. That is correct.

Senator MALONE. For many years they were given up as a bad job?

Mr. LOTTRIDGE. That is right.

Senator MALONE. So what you say is absolutely true, a new method of benefication, or a better method of benefication often means the difference between just country rock and ore.

Mr. LOTTRIDGE. That is right.

Senator MALONE. What about the fluctuation in price? What is that caused by principally that you spoke of, that might turn it back into country rock?

Mr. LOTTRIDGE. The price of any of the metals can affect it, but I am referring at the present moment to the low prices of lead and zinc.

Senator MALONE. What caused that?

Mr. LOTTRIDGE. Well, my personal opinion is that the market is flooded with foreign lead and zinc.

Senator MALONE. Foreign lead and zinc that pays less wages for mining than you do here, or what is the reason that foreign lead and zinc can beat you out here?

Mr. LOTTRIDGE. That obviously is the reason. The cost of labor is one of the largest items in any mining operation, and lower wages have permitted foreign countries to mine cheaper than we can.

Senator MALONE. What is the source in foreign areas of this lead and zinc principally?

Mr. LOTTRIDGE. Well, of course, our neighbors to the south, and the British colonies, Australia, and Great Britain herself was unloading zinc, and there was some Canadian zinc.

Senator MALONE. There is no zinc produced in Great Britain; where does she get it?

Mr. LOTTRIDGE. Australia, of course, is one of the largest sources.

Senator MALONE. What are the wages in Australia?

Mr. LOTTRIDGE. I don't know.

Senator MALONE. I saw some figures that the way they beat the wool producers into the ground is that it cost about $8.50 to raise a sheep, a unit here, and about $2.50 to raise one in Australia.

Mr. LOTTRIDGE. Yes, the ratio is about 4 to 1.

Senator MALONE. Do you suppose that is what is the matter?

Mr. LOTTRIDGE. Undoubtedly; I can't vouch for the ratio, but I presume it must be somewhere in the same range.

Senator MALONE. When did this break in the price come and what caused it that you could see? What broke the market in lead and zinc in the last 6 months?

Mr. LOTTRIDGE. Principally the unloading of large quantities of lead and zinc from foreign sources.

Senator MALONE. And you mentioned some nation that was the principal contributor. What nation was that?

Mr. LOTTRIDGE. Well, I think it is from the British sources. I am not putting my finger on them as a particular offender.

SUGGESTS TARIFF

Senator MALONE. What you are doing, however, is saying as direct as you can, that you can't compete with the low wage sources of lead and zinc, is that right?

Mr. LOTTRIDGE. That is right; neither can we in any other mineral.

Senator MALONE. So then there is a decision to be made, whether we intend to stay in business in this country with our wage standard of living, or whether we intend to average the wage standard of living with foreign nations and become sort of one economic setup.

Would you go a little further and describe what you think might be the conidtions under which we could preserve the industry here?

Mr. LOTTRIDGE. Well, Senator Malone, I think that we need some sort of protective tariff which will help our industries to operate.

We are speaking of mining in particular. Let's go back a little bit. We have talked about the preservation of our mineral resources. We have talked about the preservation of our mineral resources for defense. If the mining industry is forced to suffer a loss of price which necessitates the shutting down of properties, sometimes it is impossible economically to ever get in those properties again.

A mine may flood with water, the ground may be heavy, the mine may cave in, and those mineral resources are actually lost.

Also, unless prices are such as to encourage development and exploration, we don't know what we have underground. In other words, an undeveloped or undiscovered mineral source, that has no benefit, and that is no reserve.

Senator MALONE. What is your experience in exploration for new bodies of ore and new mines if you start today on a known deposit for exploration? How long does it generally take, on an average, to get into production?

Mr. LOTTRIDGE. Well, under very favorable circumstances, perhaps 5 years. Under average circumstances, perhaps 10 before it becomes a real producer.

Senator MALONE. If you save your own minerals and work on the basis that Mr. Ickes and many of the Government officials advocated for 20 years, to save your own minerals and import foreign minerals from across the ocean, and save your own for emergencies, when the war starts and you start developing your own minerals you are really trying to get ready for the second war after that, rather than the one then in progress.

Mr. LOTTRIDGE. That is correct; you are not saving minerals. You don't know whether you have them.

As I pointed out a moment ago, the only way when you have a body of ore is to develop it. Once it is developed and developed into a mine in most cases—I would say 95 times out of a hundred, you wouldn't be able to keep that mine open and go back into it at some subsequent time.

Senator MALONE. In order to preserve the incentive for new capital to go into the mining business, and to keep the reserves, develop these

reserves, then there is needed a long range policy in the United States.

Mr. LOTTRIDGE. That is right.

Senator MALONE. Of some stability.

Mr. LOTTRIDGE. That is right.

Senator MALONE. A tariff on some favorable and reasonable basis?

Mr. LOTTRIDGE. That is right. I am not prepared to say just what, but we need that tariff protection.

Senator MALONE. And based perhaps mostly on the difference in the wage living standards here and abroad.

Mr. LOTTRIDGE. Certainly.

Senator MALONE. Of course we know that is true. Our machinery and our know-how is available in Australia or South Africa, or any place in the world where our mining brains go, or in any other industry; our machinery is available there also and then in the large measure since World War II has been paid for by the taxpayers' money, the main difference in the cost of production actually then is the difference in wages; is it not?

Mr. LOTTRIDGE. I think that is right.

Senator MALONE. So what you are really talking about is cheap labor against a high standard of living labor in this country.

Mr. LOTTRIDGE. I think that is right; that goes back to that old fundamental.

Senator MALONE. Of course, we repealed the law of supply and demand, and several of those laws in the last 20 years, and they are aggravating us a little now again.

What is your opinion based upon your experience in the mining business, of the extent of the manganese in this country? If there were such a policy adopted by the Congress, of foreign trade on the basis of fair and reasonable competition, what adjustable tariff which the Constitution calls a duty—what do you think the United States could do over the years ahead in the production of manganese based upon your experience in mining?

MANGANESE

Mr. LOTTRIDGE. There is a considerable amount of manganese in the United States, unquestionably.

Senator MALONE. I am talking of primary ore, new or quarry mined.

Mr. LOTTRIDGE. That is right. Well, the mining industry generally knows of considerable quantities of manganese ore. It hasn't been developed; there are several reasons for that.

Our ores in this country have been low-grade ores. Therefore, we need to develop our methods of beneficiation in order to make those ores commercial. Of course, that has had its economic impact.

In other words, for a smelter to use low-grade ore just puts the price of the product out of reach, out of competition. Steel companies wouldn't be interested in it at that price. As a consequence—and I am digressing a moment—as a consequence a great amount of the ore that has been used in the production of manganese and ferroalloys has been brought in from foreign countries.

Senator MALONE. You are talking about not being interested; they are not interested because they can get it cheaper where you pay 40 cents a day or $3 a day for labor.

Mr. LOTTRIDGE. That is right; but I am also talking about the grade of ore. I do believe there must be high-grade deposits in the United States. There are very few of them that have been discovered, but there are some.

Senator MALONE. Well, we were fed the propaganda all the way during World War II that we had to get manganese from Russia. We are now getting manganese from India.

Mr. LOTTRIDGE. That is correct.

Senator MALONE. I am advised there is enough manganese in Australia to last the hemisphere for 50 or 100 years, but I want to ask you if you do know anything about the hemispheric supply of manganese after we leave the United States.

Mr. LOTTRIDGE. Yes.

Senator MALONE. Mexico, Canada.

Mr. LOTTRIDGE. Yes.

Senator MALONE. South America.

Mr. LOTTRIDGE. I was trying to think of some figures. Mexico is an available source. There is good manganese ore in Mexico. There is in Chile and Brazil, and large quantities of that ore is being imported to the United States.

Senator MALONE. We are not getting very much from Brazil at the moment.

Mr. LOTTRIDGE. Not at the moment, but you go back over the period of years and look at the imports and there have been substantial quantities.

Senator MALONE. But there are large deposits in Brazil subject to development.

Mr. LOTTRIDGE. Yes.

Senator MALONE. In other words, if Congress took some notice of the difference in the wage and living standards in this country and abroad and provided the tariff for duty on an adjustable basis, and made some effort to deal with these other countries in the Western Hemisphere, what do you think would be the chance of making the Western Hemisphere self-sufficient in manganese?

Mr. LOTTRIDGE. I think it could be very easily done.

Senator MALONE. Over a period of years ahead.

Mr. LOTTRIDGE. Yes; 5, 6, or 7 years, something like that. In South America there are many rich deposits that could be got into.

Senator MALONE. Are you familiar with the process worked out by the Bureau of Mines recently in reclaiming the manganese from the slag?

Mr. LOTTRIDGE. In a general way.

Senator MALONE. Of course, manganese doesn't remain in the steel; it is a cleanser.

Mr. LOTTRIDGE. That is right.

Senator MALONE. And it goes out into the slag, and there are mountains of this slag.

Mr. LOTTRIDGE. That is right.

Senator MALONE. Over the 30, 40, or 50 years.

Mr. LOTTRIDGE. That is right.

Senator MALONE. And I am advised by the Bureau of Mines, and we intend to get more information, that there is a very practical

method of reclaiming that manganese up to around 80 or 90 percent.

Mr. LOTTRIDGE. In general I am familiar with it. I don't know what the economic problems have been.

In other words, I think it has not been put on a commercial scale; back in the Pittsburgh area considerable research work has been done on it, and I think metallurgically it is probably sound.

Senator MALONE. The story goes—and I have had no testimony on it yet—that a man with plenty of backing started to tie up the slag piles, and then the Attorney General got in his hair because it would be a monopoly and stopped him.

In any case, the evidence is available that the Western Hemisphere could be made self-sufficient and our own production materially increased if we had some kind of a policy established on the basis of fair and reasonable competition, establishing fair and reasonable competition; in other words, fair trade and not free trade with foreign nations.

Mr. LOTTRIDGE. I think that is right.

Senator MALONE. Do you have anything else to offer the committee at this time?

Mr. LOTTRIDGE. No, I don't think so. I think the stockpiling program, of course, has been established insofar as possible, and that it is a sound thing.

Senator MALONE. You mean our investigation shows—we are not quite ready to take that up—but greater prices have been paid for foreign materials in many cases than have been paid for domestic materials?

Mr. LOTTRIDGE. I am thinking of taking up the slack in the manganese program. That has to be scrutinized rather carefully.

Senator MALONE. For example, we paid 34½ cents for foreign copper and paid 24 cents for domestic copper.

Mr. LOTTRIDGE. I am not talking about that phase of it.

Senator MALONE. It should have been reversed to make up the difference in the wage standard of living, but that it is the way Washington has operated up to now. We do hope to get a little more sense in it.

Mr. LOTTRIDGE. Yes, that is right.

Senator MALONE. You had reference, probably at least in part, to the mining bill that we passed last session.

Mr. LOTTRIDGE. Yes.

Senator MALONE. That was my bill, and extended for 2 years.

Mr. LOTTRIDGE. That is right.

Senator MALONE. The contract for manganese, tungsten, and chromite and various other metals.

Mr. LOTTRIDGE. That has been a stimulus.

Senator MALONE. That wouldn't have been necessary if we had had this other protection.

Mr. LOTTRIDGE. No, it wouldn't.

Senator MALONE. This is simply a stopgap measure.

Mr. LOTTRIDGE. That is right.

Senator MALONE. Thank you very kindly for your appearance.

Mr. LOTTRIDGE. You are welcome.

(Witness excused.)

Senator MALONE. Will you identify yourself for the record, Mr. Gibson?

TESTIMONY OF FRED D. GIBSON, GENERAL MANAGER, NEVADA OPERATIONS, WESTERN ELECTROCHEMICAL CO.

Mr. GIBSON. Fred D. Gibson, general manager of Nevada operations, Western Electrochemical Co.

Senator MALONE. Mr. Gibson, you have been here a good part of the time in the day and a half of testimony, and you know the objectives of the committee, which is to determine the availability to this Nation in wartime, and for the expanding economy and security of the country, of the strategic and critical minerals, materials, and fuels.

You also know the problems in this area, as to what might prove bottlenecks. Will you just proceed in your own words to give the committee any information that you think would be helpful?

Mr. GIBSON. I believe the only thing I could offer that would contribute to this session is to point out the possibility of shortage of power, so far as we are concerned.

We have a power contract in the amount of 232 million kilowatt-hours, and during this power-year we will use close to that amount, not quite all of it, but something in the order of 205 or 210 million.

We have installed equipment that operating in that capacity will require in the order of 290 million kilowatt-hours.

In other words, without additional production facilities, any increase in what we now have, we still will be 60 million kilowatt-hours short a year.

Senator MALONE. That is with your present installation.

Mr. GIBSON. Yes.

Senator MALONE. To reach your maximum capacity.

Mr. GIBSON. That is correct.

Senator MALONE. What do you produce, for the benefit of the record?

Mr. GIBSON. Our principal products are chlorates and perchlorates. There is a certain percentage of the chlorates that goes into the commercial market for weed killers, paper bleaching. The greater part of the chlorate production goes into the production of perchlorates. The perchlorates are used by our defense industry for various purposes. Some of them we are familiar with and some of them we are not.

We furnish perchlorates to the Army Ordnance and to the Navy. Our material that we produce, I would estimate 60 percent of it has to do with defense orders.

Senator MALONE. National defense in some manner?

Mr. GIBSON. Yes; in addition to that we manufacture electrolytic manganese dioxide. That material is all under allocation by the Signal Corps. The material is used, as I understand it, for specialized battery service.

Senator MALONE. Could you give us some indication of what you think your growth might be over the years ahead, or could be if you had the facilities.

Mr. GIBSON. Well, to be conservative, our principal client, the Aerojet Engineering Co., I believe now known as Aerojet General, have installed facilities for the manufacture of jet units for the Navy that require double our present capacity, so far as perchlorates are concerned.

Senator MALONE. What would that do to our power demand?

Mr. GIBSON. That would require an additional 225 million beyond the figure that I have given.

Senator MALONE. What does that mean in kilowatts, roughly? What is your load factor?

Mr. GIBSON. Our load factor is between 85 and 90 percent. It would probably be in the order of 25,000 kilowatts, or something like that.

Senator MALONE. What would you estimate the time element on this growth, if present conditions prevail?

Mr. GIBSON. We are just completing an expansion program of the approximate magnitude that we have just mentioned here, that has taken us approximately 18 months to build.

Senator MALONE. That is to your present capacity of 232 million kilowatt-hours.

Mr. GIBSON. I might point out that during the past 18 months or 2 years——

Senator MALONE. Or 290 it would be that you could use now with your facilities already completed, I think you said, million kilowatt-hours.

Mr. GIBSON. During the past 18 months or 2 years we have had a construction program to expand the facilities for the manufacture of perchlorates, including ammonium perchlorate, in the magnitude of around $9 milllion and it has taken about 18 months to do that job.

Senator MALONE. Do I understand that that $9 million expenditure which required 18 months now brings you up to a productive capacity that could use 290 million kilowatt-hours at the present time?

Mr. GIBSON. Yes.

Senator MALONE. On an 85-percent load factor.

Mr. GIBSON. Yes.

Senator MALONE. How many kilowatts is that, roughly?

Mr. GIBSON. I would imagine it is in the order of 40,000 kilowatts.

Senator MALONE. This extension that you anticipate will be necessary, that would require what time to construct these facilities, if present conditions prevailed, and to require the 25,000 kilowatts in addition, on an 85-percent load factor, which would be in the neighborhood of 225 million hours?

Mr. GIBSON. My estimate would be in the order of 18 months to 2 years to construct those facilities.

Senator MALONE. And during that time you anticipate you will practically double your demand for power.

Mr. GIBSON. Yes.

Senator MALONE. Have you made any investigation as to where this power is to come from, the source of it?

Mr. GIBSON. I am afraid we have looked at it from a little different angle. Of course, we have been in hopes this power would be made available at this location because this expansion could go in at this location cheaper, dollarwise, and it would be much better for us if it were a single plant.

Senator MALONE. A lower-cost operation?

Mr. GIBSON. Yes; but we have investigated the possibility of finding this source of power in some other locality, realizing that it might be necessary to carry out these expansion plans in some other place.

Senator MALONE. Well, you do have operations in other locations at the present time?

Mr. GIBSON. Very small.

Senator MALONE. Where are the operations?

Mr. GIBSON. We have some operations in Culver City, Calif., but that is more in the nature of strictly research.

Senator MALONE. It wouldn't be a place where you could have a large operation?

Mr. GIBSON. No.

Senator MALONE. Have you investigated other areas?

Mr. GIBSON. Yes.

Senator MALONE. Have you investigated other sources of power here?

Mr. GIBSON. We have kept the Colorado Commission informed as to what our power requirements might be, and we have a lot of faith that they will be able to come up with that power.

Senator MALONE. Do you have any information from them as to where it might come from?

Mr. GIBSON. We have discussed the possibility of certain types of off-peak energy from Arizona and California, and the possibility of being able to work out an arrangement whereby Shasta power might be brought into this locality.

SECONDARY POWER

Senator MALONE. Can you use secondary power in advantage in your set up?

Mr. GIBSON. We could. To qualify that, we could certainly use power, offpeak energy if we referred to the offpeak as being seasonal in nature. It would be difficult to operate our process where we might have to shut down during certain hours of the day. That would make it almost impossible.

Senator MALONE. It is just a question of the type of secondary power.

Mr. GIBSON. Yes.

Senator MALONE. Regarding this secondary power, the testimony shows it has two angles. It is secondary and it is not available the year round; then it is secondary again if the area from which it comes needs the power, because they can just refuse to deliver it; is that your understanding?

Mr. GIBSON. That is my understanding.

Mr. CAHLAN. That power is not subject to Arizona taking it prior to us if they need it. It is a firm commitment for that season of the year.

Senator MALONE. Any certain amount?

Mr. CAHLAN. Up to 300 million kilowatt-hours per year. We will give you that information when you come to us, but that is coming in from everybody and I want to correct it here.

Senator MALONE. Just to keep the record straight, it has been testified by Rollin Smith and others that there are certain amounts of power different for each month that you can be guaranteed on the secondary power. In other words, you get a certain amount in October, a certain amount in November, and all different.

Mr. CAHLAN. Mr. Neuman will answer that question when the time comes.

Senator MALONE. Yes; it won't be long now.

Mr. CAHLAN. That is in the category of firm power, and it is not subject to withdrawal by Arizona, if we serve notice on them that we want to use it.

Senator MALONE. Up to the amounts they specify in the contract.

Mr. CAHLAN. That is right.

Senator MALONE. We will clarify that for the record.

Is there any further information that you think would be helpful to the committee?

Mr. GIBSON. I don't believe so, Senator. I think the power question is the only one.

Senator MALONE. That is your bottleneck?

Mr. GIBSON. Yes.

Senator MALONE. We thank you very much for your contribution. If anything occurs to you, any information you think would be helpful to the committee, will you send it to the chairman, Senate Office Building?

Mr. GIBSON. I will be glad to.

Senator MALONE. The committee wants to be helpful, but it cannot be helpful by covering up some avenue, either a failure to deliver or a failure to guarantee the facilities.

Mr. GIBSON. Yes.

Senator MALONE. What we would like to end with by January 1—speaking as only one member of the committee, you have heard the testimony on manganese, you have heard the testimony on titanium as to its possible displacement or use in place of other strategic and critical materials, and titanium itself is a very strategic material now. You have heard the testimony that if delivery could be guaranteed, that instead of the 13,400 tons per year for which contracts have been let, with only a fraction of that amount being delivered, there might be a market for 100,000 to 150,000 tons.

Therefore, the production avenue is wide open. You heard the testimony of the steel companies that are hungry for it, and there have been mentioned companies that are ready and willing and anxious to get into the business. So far apparently there has been some blocks thrown in their way. We are almost starting to clear it up. We want to help the individual producers that are now in the business, but the people of this Nation are being scared and shocked to death every day by press reports of the danger of invasion, when, as a matter of fact, we are not producing the one material that could make us independent, probably, of the whole thing.

So the committee, as I have said, is only starting. We want to be helpful to the individual producers, but the Nation comes first.

Mr. GIBSON. We appreciate your interest and if I or my company can help you in any way, of course we will be most happy to do so.

(Witness excused.)

TESTIMONY OF ROY MARTINDALE, CONSULTING ENGINEER, LOS ANGELES, CALIF.

Senator MALONE. Will you identify yourself for the record.

Mr. MARTINDALE. Roy Martindale, consulting engineer, Los Angeles.

Senator MALONE. You are consulting engineer at the moment for the Stauffer Chemical Co.?

Mr. MARTINDALE. That is right.

Senator MALONE. In what connection?

Mr. MARTINDALE. Consultant on call for the Stauffer Co.

Senator MALONE. But in what connection, what field?

Mr. MARTINDALE. In the power field.

Senator MALONE. You heard the testimony of Mr. Art Newell, did you?

Mr. MARTINDALE. Unfortunately I was out.

Senator MALONE. Starting from scratch, you do know the objectives of the committee?

Mr. MARTINDALE. That is right.

Senator MALONE. You heard the objectives stated?

Mr. MARTINDALE. That is right.

Senator MALONE. You know the situation here? Would you, for the benefit of the record, just outline this power picture, as you see it, and anything that you think would be helpful to the committee.

Mr. MARTINDALE. First, I might state the kilowatt-hours on contract of the Stauffer Chemical Co. amounts to 139 million annually, and that supplies 3 circuits. It takes 44 million kilowatt-hours annually to supply each of the other 2 circuits they have available at the present time.

It takes another 44 million to supply a sixth circuit that requires some construction work to place into operation. According to the schedules that were made out some months ago, their operation this year would require an additional 35 million kilowatt-hours.

Next year it would require an additional 88 million, and in 1956, 132 million, in addition to the 139 million kilowatt-hours.

Senator MALONE. You are speaking of cumulative totals or in each case was this additional?

Mr. MARTINDALE. Additional to their contract of 139 million.

Senator MALONE. 156 million would be the total additional that they would need up to 1956?

Mr. MARTINDALE. 132 million, if the estimates that were presented were required by other companies that Stauffer Chemical furnish products to. If that product falls off, then of course, Stauffer Chemical products fall off in corresponding ratio.

Senator MALONE. Supposing the area here, which is one of the chief producing areas of titanium—there are only two areas of production, New Jersey and Henderson, Nev.—if the Titanium Corp. or even other companies were given contracts, additional contracts, in accordance with the testimony that you have heard here today concerning the need for the metal, then it would mean a considerable increase in your estimates for power for Stauffer Chemical Co., if those companies depended upon you for the production of chlorine and caustic soda and hydrochloric acid.

Mr. MARTINDALE. That is correct.

Senator MALONE. Let's suppose that the 15 tons per day additional contract was allocated to the Titanium Corp., and then either to the Titanium Corp. or to some other company a couple additional contracts of 15 tons per day, which would still be way below testified requirements of titanium, where would that put your demand for power?

Mr. MARTINDALE. I will have to guess at this, but I suspect the 15 tons of titanium would fully occupy or require the 6 circuits of the Stauffer Chemical Co.

Senator MALONE. That is one additional 15 tons per day.

Mr. MARTINDALE. Yes. If other demands come upon the company, it would require an additional expansion of equipment and power to take care of it.

Senator MALONE. Suppose there were one additional 15 tons per day. Assume that, and then assume too; that is, an additional 15 tons per day. Where would that land in the power requirements for your company?

Mr. MARTINDALE. I think the one 15 ton would just about fill out the 6 circuits of the Stauffer Chemical Co., which would require something on the order of 271 million kilowatts total; that is including the present 139 million on contract from Hoover and Davis.

Senator MALONE. How much additional power would be required if there was one other additional 15 tons per day allocated to the area?

Mr. MARTINDALE. I couldn't answer that, Senator, until I knew how much chlorine Stauffer Chemical would be required to produce.

Senator MALONE. Could you estimate it from your record as to what you are producing now for a certain amount of titanium? Could you make some estimate for the committee, assuming that you got all the orders?

Mr. MARTINDALE. I understand that the requirement of titanium for chlorine is variable, due to the recycling process.

If I had some constant condition, then we could estimate from that very readily, but I don't have that information at the present time.

Senator MALONE. Could you get it in consultation with Mr. Smith.

Mr. MARTINDALE. Yes.

Senator MALONE. Will you do that and furnish the committee the data?

Mr. MARTINDALE. It would depend on Mr. Smith's cooperation, but with that I think we can furnish a very fair estimate.

Senator MALONE. You can let the committee know whether Mr. Smith cooperates or not.

Mr. MARTINDALE. I am assuming we will secure that cooperation all right.

(NOTE.—Mr. Martindale later affirmed that the theoretical chlorine required per pound of titanium is 2.96.)

Senator MALONE. Well then, make the estimate.

What additional estimate can you make, with another 15 tons per day beyond the 15 tons additional that has now either been applied for by the Titanium Corp. or been offered to them, and then on the basis of two additional units—I think we are getting close to the bottleneck in titanium production.

Mr. MARTINDALE. That is on the basis of one unit and two units.

Senator MALONE. Two 15-ton per day units, in addition to the one 15-ton per day unit that Titanium Corp. has either applied for or has had offered to them.

That would really be 45 tons per day, in addition to the actual contract they have of 10 tons per day, of which they are producing about 3½ or 4 tons per day.

Mr. MARTINDALE. Yes, sir.

Senator MALONE. There has been ample testimony, I believe, starting with General Metzger, that we have not even scratched the surface in the production of titanium.

Would you agree with that statement?

Mr. MARTINDALE. I heard his testimony, that is as much as I know about it.

Senator MALONE. You have heard other testimony today from steel companies.

Mr. MARTINDALE. From the information that has been presented here in the last 2 days, there is enough uniformity of opinion, and I assume they are pretty close to being correct, Senator Malone.

Senator MALONE. We have brought these witnesses anywhere from 2,000 to 3,000 miles because of their knowledge of the subject, and we have brought them to Henderson because located in Henderson is one of the two producing companies in the United States of America.

One is located in Japan and one is located in England, but we were just in hopes that we can produce what titanium we need in the United States. It has been testified that there is no question about the availability of raw material in the United States and in Canada.

So all the committee needs to know is the demand for the metal, what it will do in the national defense program. In other words, what is holding up the program.

Mr. MARTINDALE. Yes.

Senator MALONE. So we will look forward to receiving your letter.

Mr. MARTINDALE. I will be glad to furnish it.

(This letter was not received in time to be placed in the printed hearings. When received it will be retained in the committee files.)

Senator MALONE. Just address it to the chairman, Senate Office Building.

Mr. MARTINDALE. Yes, sir.

POWER AVAILABILITY

Senator MALONE. Do you have anything additional to offer the committee?

Have you made any study of the availability of power for your additional needs in this area?

Mr. MARTINDALE. Yes; I have made some study of the availability in the Arizona pool, and also in the Los Angeles pool.

Without representing any company, I understand negotiations are now in progress to secure such power. I am fully convinced, from my long experience as an operating engineer with the department of water and power, 37 years of it, that if there is full cooperation in the Arizona and the Los Angeles and Nevada area, that there is ample offpeak power in the area to supply a great deal of the needs that you have requested.

It requires the fullest of cooperation from a number of both public and private utilities. I am saying that on my own, not representing any company. I am fully convinced of that, Senator Malone.

Senator MALONE. Has it been your experience that that cooperation will be forthcoming?

Mr. MARTINDALE. That is difficult for me to answer. It should be forthcoming in the event of a national emergency, without question.

Senator MALONE. Have you made any study of the Shasta power availability?

Mr. MARTINDALE. To some extent, yes.

Senator MALONE. Tell us about it.

Mr. MARTINDALE. Only as to the method of putting Shasta power into your local systems. It has to be done in probably one of two ways: One would be as a replacement from the P. G. & E. to the Edison Co., possibly the Metropolitan Water District operating in parallel with local utilities, which they don't probably want to do.

Senator MALONE. This cooperation that would be difficult would be between the Southern California Edison and the Bureau of Power & Light.

Mr. MARTINDALE. I am coming to that; that is the other route.

The reason I am explaining this, if power is generated at Shasta, in some way it has to be put into the system here and remain in synchronism with it, or be a power replacement program.

Following that same line of transmission, the P. G. & E. and Edison Co., and through the department of water and power on a water replacement, provided there is sufficient capacity available to the State of Nevada to use it.

The other method is that the department of water and power would have to operate in parallel with the State of Nevada, and it is not equipped to do that on account of too much equipment in synchronism which will overload the interrupting duty of the equipment.

Senator MALONE. Will you make that a little clearer.

Mr. MARTINDALE. Large systems that operate in synchronism are provided with oil circuit breakers that have certain interrupting duty on the equipment. If the interrupting duty is exceeded, then the equipment may fail when interrupting the circuits. Therefore, systems operating in parallel have to keep their short-circuit values to the extent that it will not exceed the interrupting duty on their equipment.

That is the reason each company has to be careful in operating in synchronism with another, and that is why at Boulder there is somethink like 3 or 4 separate systems all operating separately from each other.

Senator MALONE. Well, that is not the reason we have them, is it? The reason we have them is because we sold it separately and they put their own systems in.

Mr. MARTINDALE. It would require a good deal different equipment, Senator Malone, if they were to operate in parallel, heavier equipment; very definitely it was designed that way.

Senator MALONE. Let's start this power from Shasta Dam. The P. G. & E. has a contract, a postage-stamp contract of 1 mill per kilowatt-hour in taking the Shasta power any place within the area as far south as Bakersfield, is that right?

Mr. MARTINDALE. That is right.

Senator MALONE. Is the Bakersfield area where the Southern California Edison Co. ties up with the P. G. & E.?

Mr. MARTINDALE. That can be a variable proposition. A good deal of the time the P. G. & E. and the Southern California Edison Co.

operate in parallel and during such times as they operate in parallel, the power can flow directly into the Southern California Edison Co.

Senator MALONE. From Shasta?

Mr. MARTINDALE. That is right.

Senator MALONE. It can also flow the other way, from Hoover Dam.

Mr. MARTINDALE. That is right.

Senator MALONE. I think if you go down to the Dam here, down in the center of the dam, and sit there and watch those two boards operate, you can see just what you are talking about.

Mr. MARTINDALE. I have done it many times.

Senator MALONE. So have I; I was there when they designed it.

Mr. MARTINDALE. So was I.

Senator MALONE. Let's just take that from Bakersfield down into the area and use the power that you displace there up here, without it leaving this area, and see where that gets you.

Mr. MARTINDALE. I wouldn't want to answer for the Southern California Edison Co.

Senator MALONE. I don't care about that at the moment.

I am talking to you as an engineer about doing the job if you had the leeway to do it.

When I say I don't care about the Southern California Edison Co., we are not discussing them at the moment. We are discussing their facility.

PARALLEL OPERATIONS

Mr. MARTINDALE. It is a physical impossibility for Southern California Edison to operate in parallel, possibly with the metropolitan water districts, but the company doesn't operate the metropolitan water system out of Boulder in parallel with their other system, only occasionally.

Senator MALONE. But they can.

Mr. MARTINDALE. They can, largely due to switching. I understand that is their practice, and they probably have good reason for that. I don't know all of them, but I presume it is—well, no utility likes to overtax any part of its equipment and have too much interruption duty in one spot. That is why utilities operate separately.

Senator MALONE. That is one reason. I remember a long ways back, about the time that Mr. Scattergood went into Southern California, ailing in health——

Mr. MARTINDALE. That was before I arrived.

Senator MALONE. And not only recovered his health, but took Los Angeles away from the Southern California Edison and established the Bureau of Power and Light.

You have read that history, I suppose?

Mr. MARTINDALE. I was there.

Senator MALONE. Let's forget about the animosity that may exist there still, to a certain extent. If you were hired as the general manager of these three companies to put the power where it belongs, say 30,000 kilowatts of it—and you are taking much more power than that down to Southern California from here—what would you do and what problems would you have to overcome?

We are talking now on a national defense basis without trying to build up one company at the expense of another.

Mr. MARTINDALE. I think you would leave your companies operating as they are at the present time and separate a part of the Nevada system, which they can well do, and operate it in parallel with the department of water and power. That is about the only practical way it can be done.

Senator MALONE. And you would keep a certain amount of power here in lieu of the Shasta power that went into the Southern California area?

Mr. MARTINDALE. That is right; but it would require a split operation locally.

Senator MALONE. Does it require you to solve any great problem if the willingness to do it were present?

Mr. MARTINDALE. Up to an amount of, say, about half a unit of 40,000.

Senator MALONE. What do you call a unit?

Mr. MARTINDALE. I meant a Hoover unit, which is about 42,000 kilowatts.

Senator MALONE. Kilowatts?

Mr. MARTINDALE. Yes; say 42,000 kilowatts.

Senator MALONE. What is the unit?

Mr. MARTINDALE. 82,500, up to about half a unit that could be worked out fairly practically, provided the Nevada system can be separated, could take that much load the year round.

You might not want it at a constant supply the year round, but it would have a certain feasibility.

Senator MALONE. You have heard the general lament here that they have to take secondary power. They want it the year round.

Mr. MARTINDALE. Yes, I have heard that.

Senator MALONE. What are we complaining about then?

Mr. MARTINDALE. Up to the limits that I indicated, there is a possibility of doing the next thing, working out contracts to do it with.

Senator MALONE. You are talking about possibilities now and unwillingness to do it. You are not talking about the problem on a national defense basis, are you, when you get into the refusal to cooperate?

Mr. MARTINDALE. Again let me say that up to about the amount I mentioned, it is a physical possibility.

Senator MALONE. That is what we are trying to get, about 40,000 kilowatts, and we now have 30,000 allocated to this area.

So you say—and I understand your testimony perfectly, otherwise I wouldn't have suggested it in——

Mr. MARTINDALE. I am doing this on my own.

Senator MALONE. In 1935 when I was consulting engineer on the Central Valley project, looking forward to this time when it was available.

The Colorado River Commission applied for 90,000 kilowatts of power 6 years ago at my instigation; 5 or 6 years elapsed before any power was made available through a contract to the commission, and then 33,000 kilowatts were made available through a contract, 3,000 in the northwest portion of the State and 30,000 here.

We need 50,000 in the northern part of the State and at least 40,000 here, which would make 90,000 kilowatts that were applied for long before the Shasta power was taken up in any other contract, and that

would mean about 18 percent of the Shasta-Fulsom power coming into Nevada, and 64 percent of Hoover Dam power going to California.

Mr. MARTINDALE. Just about that.

Senator MALONE. Then we agree up to now. I understood you to say that it is perfectly feasible if they saw fit to cooperate.

Mr. MARTINDALE. Not perfectly feasible. I think the physical condition is that it could be, it would be possible to work out, so far as I know. There may be conditions of equipment interrupting duty of switches, and all that sort of thing, that can enter into the problem and I wouldn't have accurate knowledge of it any more.

Senator MALONE. Would you say that any of those problems would be insurmountable or would be in excessive cost?

Mr. MARTINDALE. No; I said they were physically possible.

Senator MALONE. All that stands in the way of it is the willingness to cooperate on a national defense basis.

Mr. MARTINDALE. I don't know what the price would be, Senator.

Senator MALONE. We didn't talk price at all. I am talking about getting it up here.

Mr. MARTINDALE. Yes.

Senator MALONE. It is done all over the United States, is it not, an interchange of power between power companies?

Mr. MARTINDALE. Very generally all over the country.

Senator MALONE. And with the proper charge, if there is any more load or more—we will say—distribution on the part of one company than on the part of another, that is demonstrated by the 1 million per kilowatt-hour postage stamp rate that the P. G. & E. has made and signed a contract for with the Bureau of Reclamation to distribute Shasta power and Folsom, I suppose, any place within the valley area.

You are familiar with that contract, are you?

Mr. MARTINDALE. I know of it; I am not familiar with the terms.

Senator MALONE. The limit of their transmission is a good deal farther than it would be to deliver the power to the summit, where they now do deliver power—the P. G. & E. to the Southern Pacific Power Co.—but not under contract to the Colorado River Commission. They can keep it away from Nevada any time they are short of power in California, and when they raise the price of power in California, it is applicable to Nevada.

All we wanted under this application was the same condition in Nevada, when they withdrew the power from Shasta Dam, the Bureau of Power and Light and the Southern California Edison and other companies receive power from Hoover Dam—that is to say, it was their power. So we have no authority to raise the rate because we are higher priced in Nevada or have any right to take our power back, to take Hoover Dam power for use in Nevada when we are short in Nevada.

I think you have made it entirely clear in your testimony and I appreciate it. Of course, there is nothing an engineer can do but testify to that effect if he just cuts himself loose from the companies and talks cold turkey.

Mr. MARTINDALE. Let me say again, if all the systems in what you call the Southwest, which includes the Pacific Light and Power and Southern California Edison Co.—if all of them had perfect cooper-

ation then you could do a good many things, but you still have to remember the limitations of equipment.

Senator MALONE. I think the limitations of equipment right now—and I am not speaking from personal observation, but there is a power expert with the Bureau of Reclamation who understands it—there might be a limit right now of the amount of power the Southern California Edison could transmit across the Tehachapi Range.

There might be a limiting factor which could be corrected with this cooperation that you are describing. In my present capacity I don't run the Colorado River Commission nor do I have anything to do with the negotiations, but I do still consider it my job to point out the possibilities.

BRIDGE CANYON

I have a bill in to build Bridge Canyon. That bill will go through the crucible before it passes, if it does pass, but Bridge Canyon will be built and Glen Canyon will be built.

Mr. MARTINDALE. That will be very helpful for this area.

Senator MALONE. If you are familiar with the Colorado River, you know that in 1927, 1928, and 1929 all of these dams were mapped out. There hasn't been any change since to amount to anything.

I am informed by one of the best power experts I know with the Bureau of Reclamation that once the Bridge Canyon Dam is completed and Glen Canyon is completed, Glen Canyon furnishes the storage.

Mr. MARTINDALE. That is right.

Senator MALONE. About a 26 million-acre capacity.

Mr. MARTINDALE. About the capacity of Lake Mead.

Senator MALONE. That was the projected capacity, and it was raised to 31 million, I believe. Bridge Canyon has very little storage, but has a large power capacity.

Mr. MARTINDALE. That is right.

Senator MALONE. But the two together, once constructed and coordinated with Hoover-Davis Dam, and Parker Dam, means that practically every kilowatt on this river will be firm power, if that could be brought about.

Mr. MARTINDALE. That is a little bit far, but most of it would be, Senator, and it would make a very wonderful hydroelectric system in this area if it is completed.

Senator MALONE. There would have to be certain modifications. I will let you argue with the Bureau of Reclamation expert.

I have not questioned his figures because I have never found it necessary, but he knows that it would take certain modifications of operations, but it would be an ideal situation on this river.

Mr. MARTINDALE. No question about that.

Senator MALONE. You agree?

Mr. MARTINDALE. Yes.

Senator MALONE. You also agree that if you had full cooperation of the companies and the Bureau of Power and Light and the Colorado River Commission of Nevada, that there would be very little problem, a very small problem to solve in transferring Shasta power to southern California, and additional power from Hoover Dam.

You have already testified to that, unless you want to change it.

Mr. MARTINDALE. I don't know as it would work out as a power replacement. It depends on what the Edison Co. would do in extending lines to Bridge——

Senator MALONE. I am not talking about the Bridge. I am now talking about Shasta.

Mr. MARTINDALE. I thought you meant the completion of the Bridge.

Senator MALONE. No; I mentioned that for the future.

Mr. MARTINDALE. Then I misunderstood you.

Senator MALONE. It would be a minimum of 6 years if we passed the Bridge Canyon bill next year.

Mr. MARTINDALE. I thought you referred to the other. I doubt then if there would be the necessity for the exchange of power under that condition; that is what I meant.

Senator MALONE. I think it would be minimized, but it will take the full cooperation of everybody to do what you and I agree can be done if these upper dams are completed.

We will leave those dams in abeyance because we know they are 6 years away. We are talking now about power for this area for national defense purposes. That 30,000 kilowatts of power is now under contract for southern Nevada with the Colorado River Commission. It is simply a question of making that amount of power available here, not Shasta power actually being brought into this area at all.

I think you would agree with that statement.

Mr. MARTINDALE. I don't know what the prices would be, Senator.

Senator MALONE. I am not talking about price.

Mr. MARTINDALE. I don't know about that.

Senator MALONE. We can get the price. We would have to negotiate, but your testimony agrees that with full cooperation it could be done.

Mr. MARTINDALE. That is right; I am speaking of the physical connections and full cooperation.

Senator MALONE. Thank you. Do you have anything to add?

Mr. MARTINDALE. This is probably more important to this area, and that is, there is considerable energy available to this area from the Arizona and California power pools, if the same degree of cooperation is worked out.

Senator MALONE. I fully agree with you. Do you agree with me, after listening to the testimony for a day and a half, that it would be necessary to get full cooperation, and that you could use about all the power you could get here if we could assist in breaking the log jam on the production of titanium?

Mr. MARTINDALE. Yes; there is enough power in the two areas to fulfill the conditions that were mentioned in the testimony this morning.

Senator MALONE. If you have any further information to offer the committee, I would appreciate it if you would write the chairman at the Senate Office Building.

Mr. MARTINDALE. Excepting that the latter part of my testimony was on my own.

Senator MALONE. Thank you. You are a consulting engineer, and every once in a while a consulting engineer has to cut loose if he is asked a fair question.

Mr. MARTINDALE. Yes; thank you.
(Witness excused.)

TESTIMONY OF VAN ENGLESTEAD, DIRECTOR, CIO OF NEVADA

Senator MALONE. Will you identify yourself for the record?
Mr. ENGLESTEAD. I am Van Englestead, representative of the United Steel Workers of America, CIO.
Senator MALONE. Well, you have become a part of this area, Van. When I knew you you were a workingman in Pioche.
Mr. ENGLESTEAD. Senator Malone, I still consider myself a workingman. I have just changed my surroundings slightly.
Senator MALONE. I never knew you to do anything but good up there.
We have a problem here. I guess you have listened to the testimony for a couple of days.
Mr. ENGLESTEAD. I am sorry, Senator, I only got here yesterday morning. I wish I could have, because it is very interesting.
As to what has transpired since yesterday noon, I am completely in the dark.
Senator MALONE. The testimony has been that there is almost unlimited opportunity for development in this area if we can whip the production problems, get the bugs out of the production problems in producing titanium in this area, and if power can be available.
I didn't intend to ask you any technical question. There is a considerable problem facing the Nation. We have slowly become dependent over the last 20 years, on foreign nations across the oceans, unfortunately, for many of the materials and minerals that we cannot run our economic system in peacetime without, and certainly couldn't fight a war without.
One of the metals is tungsten, with which you are familiar; whether you know anything about it technically or not wouldn't be necessary. You have worked in the area and many of your colleagues are still there.
You have worked in the lead and zinc areas in the production of those metals. You know the effect on the area, on the employment, when excessive amounts of such materials are imported from what I often refer to as "sweatshop labor nations" or lower wage standards of living nations.
We have become dependent on Burma, southern China, and Mexico for tungsten that we use in the United States, simply because in Burma the wages may be 40 cents a day—when they receive wages—with no protection to the worker at all in the matter of unemployment insurance, industrial insurance, social security, and so on, that we have in this country.
As a matter of fact, the wages in some countries per day do not more than equal the industrial insurance payments and the unemployment insurance payments and social security payments for a worker in this country, exclusive of his wages.
So that is the problem, and you might say it applies to lead and zinc as well. The lead and zinc market has been broken lately through the importation of lead and zinc from the low wage countries in such quantities that it is no longer needed from the high wage living standard areas like Pioche.

I just referred to Pioche because it happens to be located within our area, but there are other areas like the Kansas-Missouri-Oklahoma areas, and they are on the verge of closing down because of this importation of low wage produced material.

I will just ask you a general question and will be glad to have you discuss it. What do you think the conditions laid down by Congress would have to be over a long-range basis to encourage investments and protect the workers who are in the many industries?

I only named three minerals. There are also many industries, machine tooled industries, watch industries, and they are all in the same boat.

In 1934 the Trade Agreements Act transferred the constitutional responsibility of fixing duties and excises—as we refer to tariffs and import fees—to the executive, meaning the State Department. They have used their own judgment in the last 20 years in contracts, lowering these excises to where we have now reached the point where there is no protection for the worker or the investor.

What do you think Congress ought to do to reestablish the confidence in the worker and the investor in industries affected through the low wage standard of living, wherever located?

MUCH UNEMPLOYMENT

Mr. ENGLESTEAD. Well, Senator, that is quite a question for me to attempt to answer, but I do have a few definite opinions on it.

Senator MALONE. You understand it, Van, or I wouldn't ask you.

Mr. ENGLESTEAD. In my mind, and thinking of my organization, we are certainly concerned and alarmed at the situation. We look around and see the old established industries fold up and walk away. We wonder why that has to happen.

We realize that the cost of production for lead and zinc or manganese, or whatever it might be in this country in excess of what it costs in other countries, but we still say we have to live, the working man has to live. We know that if you pit foreign labor against the American labor market with no barriers or anything to offset the balance anywhere along the line American industry is going to suffer.

In the Pioche area, where I am not too familiar with the figures, but say 6 years ago we had employment in the area of between four and five hundred miners, and I think now we probably have 150. That is stretching it quite a lot, if we do have 150 miners employed in the area.

The same thing has happened around the Utah area, around Park City. We have had a group of underground miners up there in excess of 4,000 or 5,000, and I think that figure now is down to less than 2,000.

That has caused an awful disruption on the working people to have to go out and seek new jobs, leave established homes. It is also an awful hardship on industry, and the mining indutry particularly, to have to close up, because in all probability—at least I have been told this, and I believe the people who told me know what they are talking about—that it is practically prohibitive to reopen most of those mines, although the life expectancy still had from 10 to 50 years to run. But the expectancy now is about gone because the cost is prohibitive to go back unless an emergency was such that you had to go back and

reopen the mine. That would be the only way. The mining companies themselves wouldn't be able to reopen under their own steam. They would have to have help, and I mean it would take an enormous amount of help without the people to go ahead with the know-how to do it.

We hate to see the mining interests or the miners themselves broken up and channeled into new jobs because we understand and realize that in the event something does come in the future where you are going to have something like that you have 4 or 5 years of training periods to produce personnel and miners and everybody else that can satisfactorily carry on that type of operation.

Somewhere along the line I believe there should be a balance struck somewhere to insure and protect the mining industry generally throughout the United States, regardless of the type of metal or what it might be. You can see the supports put on tungsen and manganese, and that is about the only thing we have left now that is interesting any mining companies at all. There is quite a search for manganese because they have a guaranteed price for 2 or 3 years. It doesn't allow them, the way conditions are, I don't believe, to compete too much with foreign metal, but it does allow them to go out and get established and hope that after that period has expired that they would still be able to operate.

Senator MALONE. You are talking about the type of legislation that my bill that was passed gave them a 2-year period, more or less, of life.

Mr. ENGLESTEAD. That helped quite a lot.

Senator MALONE. But it wouldn't be necessary if you had some equalizer as a principle between the low wage labor in the foreign nations across the oceans and the wage standard of living here?

Mr. ENGLESTEAD. No. If you had some sort of balance, that wouldn't be necessary at all. I bring this out, what the mining industry is doing, because they are guaranteed some protection, but if the protection was a normal, standard thing set up that they could weigh and see every day, and know what the operation procedure was going to be, I don't think you would have too much trouble. That is the only place it could be established.

NATIONAL-DEFENSE FACTOR

Senator MALONE. Isn't there a national defense factor there?

Mr. ENGLESTEAD. That is the biggest thing. If something can't be done to keep these mines in operation, when the national defense factor does come along, it is going to be a very critical thing. You are going to lose what production is available now and would be then, and there would have to be a period of 2 or 3 years of hard work and an awful lot of expense to ever get under normal production.

Senator MALONE. You are familiar with the talk coming out of the State Department that when these men are thrown out of work, that they will try to establish some kind of training school to train them to do some other kind of work.

You have heard that propaganda. What do you think of that sort of procedure?

Mr. ENGLESTEAD. Well, it would be very nice if they could and would, but I don't have too much faith in that. When a man gets on the bum, he is on the bum, that is all.

Senator MALONE. If he learns to be a good miner, it takes him 3 or 4 years, does it not, just as it takes about as long to become a real good miner as it does to get a college education.

Mr. ENGLESTEAD. In some respect I would say maybe what you learn to be a miner would come a little harder than a college education. They are a specific breed of men who have a lot of pride. They are very nice individuals, maybe a little rough, but they are proud of the occupation, and without an incentive to keep those guys in the mines, or maybe that is one of the reasons the miners are in trouble. The mine operators have to produce an incentive to keep the guys in there along with other industries.

Your life expectancy isn't as long as in some factories, and the hazards involved are a little bit more, but it is the type of job where the livelihood appeals to a certain type of people and they stay with it. I can't pass a dump that has 2 tons of muck, without wanting to see what is in there. It is a curiosity, and you hear people talk about mines and you hear, "Well, it is about time you put on your hat and went back to the trade."

But until something is done, lead and zinc is the only thing I am well acquainted with around the area, and unless something is done here, we can write off lead and zinc production as such, unless something comes out with the production of copper or something else in conjunction with it, but you can just about write off lead and zinc production in the Western States.

Senator MALONE. As an illustration, we gave $25 million to a company to produce lead and zinc in Morocco, and we are encouraging foreign production. I will agree with you.

I worked in the mines at one time, in the mills as a boilermaker's helper one time, and I agree with you they are a little rough, but they know their business. If they do know their business they can become attached to their occupation.

Well, Van, the committee appreciates your appearance here. I hope this is the beginning of your cooperation. You know the objectives of the committee, to determine the availability of these materials called strategic and critical in wartime. The minerals you have mentioned are only two out of more than 77. We are taking them one at a time. We have had a 3-day hearing in Seattle.

I might say, I think you will agree that the investors' interest and the workingman's interest are common to this problem. When you whip the problem, then the workingman and investors have another problem of determining wages and working conditions, but there is no use arguing about that until we whip the first problem.

If we are out of production, there is no problem between the workingman and the investor because there are no jobs or investments.

Mr. ENGLESTEAD. That is right. I might say, Senator Malone, that maybe you are not too familiar with it, but over the past 2 or 3 years the United Steel Workers have sent groups to Washington to try to arouse some interest in the lead and zinc mining in the west.

They haven't been too successful. One of the reasons they haven't, probably, is that they didn't go at it in the right manner. They went in and buttonholed and talked to practically every person on Capitol Hill if they would sit down and listen to them. I don't think they made the right approach by not looking to someone who was really interested in the problem, and could give a little organized help.

The steel workers want to, or have stated that they intend, to do something to protect the plight of the American worker. They are getting concerned now as to importation of iron ore and steel and things like that.

It keeps increasing all the time, and of course, the organization I belong to is predominently steel workers, and that hasn't come into their attention too much until lately, but President McDonald in February said in his speech, when he was installed as president of the steel workers' union, that he intended to look into this and do something about the importation of goods or raw materials.

He didn't necessarily come out and itemize the things that was jeopardizing the well-being of the American worker. I think you can get every bit of cooperation the committee needs from that group, and I think you will find as they become acquainted with the problems they will cooperate, and I am sure you can acquaint them with it.

Senator MALONE. The same problems confronted the watchmakers. The watch I have on my wrist was made in Switzerland. The tariff was down, so there was no protection to the American workers, and these are the same American workers that make the instruments, the delicate instruments, for the airplanes in national defense as well as commerce.

So when we lose these workers, like the watchmakers tell me it takes 4 or 5 years to become a good watchmaker, and it is a selective thing, so that many of them never do.

When you lose these workers your national defense effort is weakened. You have the same in the machine-tool industry. There is no question but what Belgium can whip you to death in the machine-tool industry.

You are selling everything to the Government, and when that quits, of course, there could be a very serious displacement.

Well, Van, I appreciate very much your appearance here, and I hope it is just the beginning of the cooperation with the committee.

Mr. ENGLESTEAD. Well, Senator, if I can be of any help I will be glad any time to, because I am vitally concerned with a third of my coworkers out of work right now, and I look and see Mr. Buehler in the mining business, and I have known him for a long time, and I know that for about 3 years he hasn't turned a wheel. I am sure he would like to get back into production.

Senator MALONE. He is probably responsible to a good many investors and you are responsible to a good many workers.

Mr. ENGLESTEAD. We have been associated pretty much along certain lines. We have been in lots of dealings together as labor and management, and when he is not operating it hurts the boys, too.

Senator MALONE. I want to say that I have observed the Pioche area over a period of close to 30 years, and I have never seen an area where there was more cooperation between the workers and management. I think it is one of the best in the United States.

Mr. ENGLESTEAD. I think the cooperation is good. I have always said that we have the best operators in the country. They were gentlemen and decent, and we always got along. We had petty difficulties, but nothing was ever major, and that is why I say we can appreciate their problems, because they tell them to us and we realize they are

the truth. We know their troubles, so we become concerned with them.

Senator MALONE. Thank you, Van, very much.

(Witness excused.)

Senator MALONE. Julian, will you identify yourself for the record.

TESTIMONY OF JULIAN MOORE, MANAGER, BASIC MANAGEMENT, INC., HENDERSON, NEV.

Mr. MOORE. Julian Moore, manager, Basic Management, Inc., Henderson, Nev.

Senator MALONE. You have heard the discussion for 2 days and know the objectives of the committee. Your experience in this area has been long and in detail. I know you are familiar with the operations here and the efforts to get established in the Colorado River Commission, and I have no particular questions to ask you, but if you have any general statement of information that you think would be helpful to the committee, we would appreciate having it.

Mr. MOORE. Senator Malone, I don't think I can add anything to what has already been said. I recognize the thing that you are trying to point up, and we have been familiar with the shortage of power in the area a long time. The Colorado River Commission is trying desperately to meet the increasing demands for power.

On the level that I work, we are concerned with the operational details of the water system, and things like that, and we must keep those things in mind. I do think that the work that you are doing here is going to be of great benefit to Henderson particularly, and that, of course, is something that I am vitally interested in.

I have watched this thing grow out of almost nothing and develop into a substantial chemical and metal operation here, which we are all very proud of.

Senator MALONE. I was a little ahead of you. I came down here when there was nothing between Las Vegas and the river in 1927, and only about 3,500 people in Las Vegas.

I have seen it grow from that status, and I am even more interested in it now. It would be impossible to be any more interested in it because we have put out the facts and had the full cooperation of the present Acting Chairman of the Commission, and were successful in getting 36 percent withdrawal, 36 percent of the firm power of the project at Boulder Dam—now Hoover Dam—which started this off.

Then you have one-fourth of the Davis Dam power to throw into the pot, and now have a bill in to build Bridge Canyon and we hope to keep it moving. We are also interested in the water, the 900,000 acre-feet of water that will be available for many years ahead.

Power and water is your need at a price that can be used, of course.

Do you have anything further?

Mr. MOORE. No, sir.

Senator MALONE. If at any time you think of anything which would be helpful to the committee, we would appreciate it if you would write the chairman, Senate Office Building.

(Witness excused.)

Senator MALONE. We will take a short recess at this time.

(Short recess.)

Senator MALONE. Mr. Cahlan, will you identify yourself for the benefit of the record?

TESTIMONY OF A. E. CAHLAN, ACTING CHAIRMAN, COLORADO RIVER COMMISSION, HENDERSON, NEV.

Senator MALONE. You have listened to the testimony for nearly 2 days now, and you know the objectives of the committee, which is to be helpful in production to make available to the United States the strategic and critical minerals, materials, and fuels in time of war and for the expanding economy.

I know in general the efforts of the Colorado River Commission, but the committee will be very appreciative of anything you may have to say that would further this program.

Mr. CAHLAN. The biggest obstacle that we have run up against in obtaining additional power for this area has been the inability of the industrial plants at Henderson to contract for over a long period of time for firm power. I think that is one point that should be stressed, that the maximum contract we have been able to get for this additional power has been on a 5-year basis.

Arizona has insisted that we contract for firm power on a 10-year contract. That was offered to the people here at the plant, and they said they were unable to contract for it on that period of time.

The committee will be interested, of course, as you know, Senator Malone, that the State of Nevada in making these contracts acts largely as a liaison agent, although we are the contracting party. We have to make sure that the State is made whole on any contracts that are made, and when we sign up for power we have to know that it is going to be sold for the period of time that it is signed for. That is one point.

Secondly, with regard to Shasta power, that has been discussed many times with the heads of the industrial firms here at the plant.

The low power factor and the necessity for firming that Shasta power has so far been an obstacle that we have been unable to overcome in the minds of the potential users here at the plant.

Those points occurred to me as we went along here. I don't know how far you want to go into this power situation for the record.

I might give these figures which I think probably will be of help. Nevada has from Boulder Dam 741 million kilowatt-hours of power per year.

We have firm from Davis Dam 236 million kilowatt-hours per year making a total of 977 million firm power. That has been split, 355 million to the so-called 3 southern Nevada contractors, which are Southern Nevada Power Co., Overton Power District, and Lincoln County Power District.

Six hundred and twenty-two million kilowatt-hours goes to the Basic plant, which is in the Hoover-Davis pool, and carries a Boulder-Davis pool rate that Mr. Smith referred to.

In our contracts with the Basic plant operators, we agreed to use the best efforts of the Commission to obtain additional power from whatever source is obtainable in this southwestern area. We have from time to time taken estimates from the Basic lessees, so-called, to ascertain their power needs and project it over a period of time into the future.

We have conducted our efforts to have that power available at the time they need it. You are familiar with the capture and return clauses of the Boulder Dam contracts. We have now withdrawn all of the power from there.

There is from time to time additional power available from Davis Dam, in addition to this firm power. We use some of that power, have used some of it this year. The Commission has made, and will be happy to make available to you, Senator Malone, or give you the figures from it, at the request of the lessees at the Basic plant, a survey of a steam plant to be installed in this area, using either natural gas or oil.

We have that survey, which we will be happy to turn over to you, or Mr. Neumann can read into the record the salient points of that survey as to price and the capacity, and so forth.

If you want to ask some questions now we will answer them for you.

Senator MALONE. Of course, my personal interest I can discuss with you at any time that which might go further than the committee's interest.

The committee's interest is centered in the necessity for the products that are being produced here in the national defense picture, but also in the matter of the growing economy of the Nation.

The Insular Affairs Committee is charged by Resolution 143 to determine the availability of the materials. It has been made part of the record here at this time.

Titanium is one of those materials, and other products manufactured in this area, which are necessary to the production of titanium in making that metal available in quantities necessary for national defense, and of course, for the expanding economy as you have heard testified here yesterday and today.

PRODUCTION LAG

It seems to the chairman of the committee that there is an unusual, an unavoidable lag in production, but at least there is a delay that is very embarrassing.

Since this area is 1 of 2 productive areas in the United States of America in this important matter that you have heard described at considerable length, speaking as one member of the committee we would like to know what the prospects are and what is being done about it to increase the production of that important metal here.

We will take up the Du Pont Co. in the New Jersey area in a Washington or New Jersey hearing.

You heard the testimony that for the national defense the plans, of course, are in the making, but they don't dare let contracts on the basis of the use of titanium that they would like to have because they are not only afraid it will not be available, but that it is almost certain that it will not be available.

So it would seem to the chairman of the committee that the field is wide open. For the benefit of the committee, we would like to have the ideas of the Colorado River Commission as to just what they can do, or are prepared to do, or what they think would happen if additional contracts were available for the titanium, which would mean a substantial increase in the production of some other industries here, notably the Stauffer Chemical Co., in chlorine, caustic soda, and hydrochloric acid.

I think you heard the testimony of the representative of these companies, that they would need large additional amounts of power. I know you are exactly right that the State must be safeguarded when you sign a contract from loss in the event the power is not used.

That was the reason, of course, when I was secretary of the commission in 1927 to 1935 that I fought so hard and was successful in getting the right to relinquish the power under certain conditions and to secure it again without prejudice because at that time we used practically no power in the area, and there was no place to take up the power.

Now you do have a little more latitude, but there is a limit to that latitude of course.

So the larger your power use grew, the greater your latitude in more power, but I hope that the information that has come to light during these hearings will help bridge that connection between the actual users; that is, the users of the power now in use and their potential use and the work of the committee.

I know that the committee is very anxious to do anything they can to furnish the necessary power.

So it would be helpful I think if you made a part of the record your negotiations and your status in regard to securing the secondary power that has been mentioned.

(The information referred to follows:)

COLORADO RIVER COMMISSION OF NEVADA,
Henderson, Nev., September 30, 1953.

Senator GEORGE W. MALONE,
Senate Office Building, Washington, D. C.

DEAR SENATOR MALONE: Mr. A. E. Cahlan thought that some data concerning the probable cost of power if generated by steam at Henderson, would be of value in your report on titanium production.

In searching for additional power sources for this area the Colorado River Commission of Nevada engaged the Stearns-Roger Manufacturing Co. of Denver to make a study of the feasibility of a generating station to be located at Henderson, Nev. That company submitted its report on January 15, 1953. In that report it was recommended that if Nevada could not obtain adequate firm power at satisfactory price from other sources, a steam plant of 60,000-kilowatt capacity be installed near the Basic Magnesium area. The proposed station was to contain three 20,000-kilowatt generators. Total energy costs are quoted from the report:

Mills per kilowatt-hour

Units in operation	Annual million kilowatt-hours	Fixed charges	Fuel cost		Total	
			Gas	Oil	Gas	Oil
No. 1	160	8.76	3.12	6.16	11.88	14.92
Nos. 1, 2	320	4.38	3.12	6.16	7.50	10.54
Nos. 1, 2, 3	480	2.92	3.12	6.16	6.04	9.08

"Gas has been selected as the base fuel with oil as a standby. This selection was basesd on an estimated cost per million BTU's of 25 cents for natural gas, and 52 cents for fuel oil which is equivalent to $3.22 per barrel for bunker C oil."

Very truly yours,

C. F. NEUMANN,
Electrical Engineer.

Mr. CAHLAN. Senator, I might say this. With regard to the testimony of Mr. Smith, and also the suggestion of the chairman that there

might be an additional contract, or 2 additional contracts, perhaps that 15 tons each of titanium, it is the feeling of our commission, from the investigations we have made, that that power can be made available provided the Titanium Corp. is in a position to contract for it on a firm basis over a period of 10 years.

Mr. Neuman will give you the details of our negotiations with Arizona. We have the assurance of the Arizona Power Authority that they will not only give us the benefit of available power in Arizona now, but that they will install an additional steam unit to take care of future power needs of the State of Nevada, if we can contract for it.

I think the period of time will coincide with the need of titanium for that power. The chairman is well aware of the fact that the Colorado River Commission is in the State of Nevada, and is not in the power business. The Arizona Power Authority is definitely in business, with the full backing of the State of Arizona.

We found that it would be cheaper for us to deal with Arizona on this power situation, and it would be cheaper for us if the Arizona Power Authority will put in additional steam capacity and deliver it here, than we could put the same capacity in here ourselves.

That is the reason I make the general statement that if these contractors will come to the Colorado River Commission of Nevada and say they are in a position to contract for so much power at a certain date—Mr. Martindale, I think, made the same statement in general terms—that we will be able to get the power for them, but the stumbling block has been that they have not been able to come in and contract for that power.

They haven't had the orders or the ability to do it.

Senator MALONE. You might say they have not had the ability to produce the material and the confidence perhaps to take the additional contracts that might be offered and the confidence that they can produce it and use the power on a schedule.

Is that about a summation of the problem?

Mr. CAHLAN. That is right. I think the commission has no doubt, and I have no doubt that with the cooperation of your committee and the Congress of the United States, in recognizing this as a very vital need, titanium produced at Henderson, that we can use Shasta power, work out some way to use it here.

Senator MALONE. You heard the testimony of Mr. Martindale as an engineer not representing anyone but himself, and he has had wide experience, and you heard him testify that there was no insurmountable problem except probably a personal——

Mr. CAHLAN. That was on transporting the power here.

Senator MALONE. Well, to complete what I was saying for the record—the personal relations problem between the companies involved in the transfer.

Mr. CAHLAN. That has been our feeling. The only obstacle that we see is firming the Shasta power.

Senator MALONE. Have you been advised as to what percentage of the time this power would be made available, or have you made any estimate as to how much power it would take to firm it?

Mr. CAHLAN. Mr. Neumann, can you answer that question?

TESTIMONY OF C. F. NEUMANN, ELECTRICAL ENGINEER, COLORADO RIVER COMMISSION

Mr. NEUMANN. In looking this up, there were 4 months of the year when the supplementary power that we could get from Arizona couldn't be considered as firming the Shasta power. During those 4 months we would be somewhat limited in the amount of power available.

We could have a fairly sure use of those 2 sources together for 8 months of the year, and coupled with the ability to regulate our use of Hoover energy, we might fill in the other 4 months by holding back the generation at Hoover until those 4 months, and then using it rather rapidly to smooth out that picture.

Senator MALONE. You are talking about firm power in the area here, complete firm power?

Mr. NEUMANN. It would amount to practically firm power if we could combine these three sources.

Senator MALONE. But it is of interest to the committee, as far as producing titanium is concerned, to note that they would be satisfied with less than firm power, so why the hesitation on Shasta power, because it is not firm power where you are willing to depend on it, which is much more nearly firm than the power in Arizona.

Mr. NEUMANN. I believe that the Shasta power has very wide variation in the amount that is available, and at least 2 or 3 or 4 months of the year it would be at a rather low value, giving us in the neighborhood of 4 to 8 million kilowatt-hours per month.

At another time of the year it would give us as high, possibly, as 25 million kilowatt-hours in a month.

Senator MALONE. You are talking about buying power over here for 6 mills a kilowatt-hour when you only have an erratic supply for 6 months, with a different supply for each month, and being satisfied with that supply.

Mr. NEUMANN. Coupling that with the availability of steam power from Arizona, we can form a fairly firm supply by blending the two, plus the power available from Hoover Dam.

Senator MALONE. I still don't understand why the Shasta power doesn't fit into the picture just as well.

Mr. NEUMANN. The Shasta would be in the same category as the Hoover power—I mean as the Arizona power during certain months which would have to be blended with Hoover control in order to make a uniform supply for industry.

Senator MALONE. Is that a difficult matter?

Mr. NEUMANN. At present it is working all right. We are blending the use of Hoover-Davis power in that manner.

Senator MALONE. Is that a customary procedure?

Mr. NEUMANN. The time might come when the amount of water required for irrigation would interfere with our full use of Hoover for that purpose. It does not at present.

Senator MALONE. Let's explore this a little further.

You understand the chairman has no idea of forcing you to take Shasta power, but he is interested in finding out whether you are interested in considering it or not. In this Shasta contract it is secondary only to the extent that there are certain months it varies in

the delivery, but it is not secondary in that they can take it away from you. It is firm as far as their delivering the amount that they can deliver each month, with no diminution on account of someone else's demand.

Is that true of the Arizona power?

Mr. NEUMANN. We believe it is true, according to the letter of intent given to us by the Arizona Power Authority, wherein the smallest amount guaranteed us is 11,000-kilowatt capacity in 1 winter month, followed by 4 months of 16,000 kilowatts.

A year later those quantities are doubled by the addition of another steam unit to be then in operation.

Senator MALONE. Is the steam unit you are receiving all this power from—is that where you are receiving this power?

Mr. NEUMANN. The units that this power will come from are steam units in the steam plant. One of them will be on the line June 1, 1954; the second one a year later.

Senator MALONE. And they would sign a 10-year contract on that basis?

Mr. NEUMANN. They will sign a contract.

Senator MALONE. What happens after 10 years?

Mr. NEUMANN. The contract is renewable 1 year at a time after that, at the agreement of both parties.

Senator MALONE. Ten years passes pretty quickly, I have found, after being in the business 30 years.

I only point out that the Shasta contract probably would be on the same basis as Hoover Dam power contracts with the Bureau of Reclamation, and you would probably be assured of power as long as the Shasta Dam produced power.

Mr. NEUMANN. That amount of power would, of course, be very welcome in our endeavor to serve local industry.

By the time the 10 years is up conditions will have indicated what further step would be required to provide a firm power supply for future needs.

Senator MALONE. And if experience is any basis for projecting the future, I presume you have been in this business for quite a while, and fuel goes up but hydropower doesn't change much in price. So at the end of 10 years you might find yourself with power here that wouldn't be satisfactory to your industry.

Mr. NEUMANN. At the end of that time, of course, there is some possibility of additional hydro upstream development in this area.

Senator MALONE. That is right. We have a bill in to build Bridge Canyon and Glen Canyon and they will be built. But you have practically discarded the situation as far as Shasta power is concerned.

You are really not working very hard on that, are you?

Mr. NEUMANN. I can't say about that, as that is being handled by the engineering committee. Presently we don't consider it as available in the near future.

Senator MALONE. Of course it is going to be available now if it is going to be available at all.

Is there any work being done on that?

Mr. NEUMANN. I will have to refer to Mr. Cahlan on that, as I am not following that at all.

Mr. CAHLAN. We signed a contract for 20,000 kilowatts.

Senator MALONE. Wasn't it 33,000?

FORCE DELIVERY OF POWER

Mr. CAHLAN. Yes. I think the last record we have on it, Senator, is within the last 3 or 4 months, that it couldn't be delivered.

As I recall also, and I think you will agree, we agreed that we were going to work together on the thing and force delivery of that power here.

Senator MALONE. Well, I am still available. There was a ruling made by the administration then controlling Washington affairs that the Colorado River contracted with a private power company to distribute the power, that it was still subject to withdrawal; is that right?

Mr. CAHLAN. Yes.

Senator MALONE. And I said at the time that I would introduce a bill to amend the reclamation law so it wouldn't be available, further available for withdrawal if and when the Colorado River Commission contracted with the private power company, or anyone else, to distribute it; but that I didn't think we needed to pass a bill if we changed the administration.

Was that about the status at that time?

Mr. CAHLAN. Yes.

Senator MALONE. The administration changed and the ruling was changed. Now all you have to do is to receive your power, contract for its distribution or delivery with either a private power company or the municipally owned company or a private user, and it is no longer subject to withdrawal.

That is a definite statement by the Secretary of the Interior. So the amendment to the bill is not yet. The status of the amount has been about 6 years—was it about 6 years ago that you applied for 90,000 kilowatts of power to the Colorado River Commission?

Mr. CAHLAN. I think about that. It was right after I first went on the commission, Senator.

Senator MALONE. During that time many of the contracts were made with municipalities and other users in the California area, while nothing was done about the application of the Colorado River Commission.

Also I am persuaded that not very much agitation came from the Commission.

Mr. CAHLAN. For a time that was true.

Senator MALONE. But last year there was a definite awakening. Without going into any detail, a part of the 90,000 kilowatts, the 33,000 kilowatts was definitely assigned to the Colorado River Commission of Nevada under the customer preference clause of the reclamation law, which is just about the same proposition as contained in the special legislation, the Boulder Dam project, formerly the Swing-Johnson bill, so you could get this power under the same conditions as the bureau of light and power in Los Angeles received Hoover Dam power.

That means that no shortage existed in California. You would suffer no diminution in your 33,000 kilowatts by virtue of the shortage of power in California, and no effect would be had on the price of power.

In other words, you have had hydroelectric power of your own from the Shasta area, and you as an engineer are aware that while

it costs to install hydroelectric power, there is no fuel involved and no expense except the operation maintenance and labor, and over the years, even with extreme inflation, there is very little change in the cost of power.

Is that right?

Mr. CAHLAN. I think it is.

Senator MALONE. In other words, in 1935 they set 1.63 for falling water per kilowatt hour of water at Hoover Dam, which amounted to roughly 2 mills, and that price has not changed even though inflation has been rampant over the entire period.

Is that right, Mr. Neumann?

Mr. NEUMANN. I think that is reasonably correct.

Senator MALONE. But there has been a terrific change in the price of power generated through fuel, whether diesel or steam.

Is that right?

Mr. NEUMANN. Yes, sir; that reflects the increased cost of fuels, naturally.

Senator MALONE. Well, then, in your opinion as an engineer, is it desirable to have hydro power, is that more desirable than steam power?

Mr. NEUMANN. The hydro power, while cheaper, should be supplemented, I believe, by some steam capacity because the steam capacity is available whenever fuel is available.

Hydro has its poor years, and sometimes is reduced in available amounts because of poor water years or a succession of such years.

Senator MALONE. They have a certain degree of firmness. In other words, you count on that, but you are contracting for your initial basic supply of power from steam as well as your secondary power, or the hydro power.

You are depending entirely on steam, so I want to bring out from your own testimony what is the comparison of stability of price over the years between hydro and steam.

Mr. CAHLAN. I don't believe that I can give any figures on that.

Mr. NEUMANN. The firming of hydro by steam in this case is largely forced upon us by the lack of any further hydro to depend on. If we had up-river development of hydro, then perhaps this contract for steam would be less attractive.

Senator MALONE. You are looking forward to that? You mentioned it in connection with steam power and renewal of the contract.

Wouldn't the hydro still be more attractive when you get additional hydro, because you know you are going to keep your hydro from Shasta or from any other source where the contract is equally stable?

I just want you in your own words to tell me, for the record, so when I read it I will know whether you are really working on this problem or not, whether you want it or not.

Mr. NEUMANN. A steam supply, particularly if local, provides a standby source bridging over such catastrophes as line disasters, which may cut off hydro projects generally remotely located.

Senator MALONE. You still haven't answered my question as to whether the basic supply of hydro is better than the steam supply for continuous use.

You know, as well as I do, that you always use steam power for secondary power if you can get it, because the installation is cheaper.

You also probably know that you have as much of your basic backlog supply of hydro that you can get because the installation is more expensive, but there is no change in the price as you go along, and no fuel price to pay or the operation maintenance is at a minimum.

You have been in the business long enough to know how you coordinate the use of power. You always have a backlog or basic log of hydro if you can get it and supplement it with steam; do you not?

Mr. NEUMANN. That is right.

Senator MALONE. What are you doing here?

Mr. NEUMANN. Our basic supply here is hydro through Hoover-Davis and Shasta if we can get it, and it will be supplemented by steam supply from Arizona.

Senator MALONE. Well, what effort are you making to get it?

Mr. CAHLAN. Senator Malone, let me answer that question.

Following through on the conference we had, we led up to the point of getting the power. Then the Governor and the engineering committee attempted to arrange a joint meeting between the Pacific Gas & Electric Co., the city of Los Angeles and the Southern California Edison Co., at which time this matter could be thrashed out on top level.

There were to be the top men of each of the three organizations there.

Efforts over a period of weeks went into this, and they failed to get a joint conference.

Subsequently the Governor and the engineering committee met in Los Angeles with the heads of the Bureau of Power and Light and the Southern California Edison, and later with the Pacific Gas & Electric Co.

I think either Mr. Strong or Mr. Buehler can tell you what happened.

Do you want to outline those meetings, Jack?

TESTIMONY OF J. H. BUEHLER, COLORADO RIVER COMMISSION

Mr. BUEHLER. At a meeting with the Edison they definitely advised us that they would be unable to exchange Hoover energy for Shasta energy, since they were using their Hoover energy exclusively for peaking and we left there very much disappointed. They definitely turned us down on any exchange of Hoover for Shasta. That was the Edison.

We also met with the P. G. & E. in San Francisco, and they took a similar stand.

Senator MALONE. They said they wouldn't transmit Shasta power as far as Bakersfield, or wherever their connections are made with the Southern California Edison?

Mr. BUEHLER. That is right.

Senator MALONE. Did they do that in writing, turn it down in writing?

Mr. BUEHLER. We do have a letter from the P. G. & E. in which they set forth the reasons why they couldn't transmit that energy for us. That letter however at the time was based on some law that they intended to pass in the California Legislature.

Senator MALONE. That they controlled?

Mr. BUEHLER. Yes. However, that resolution was later turned down by the California Legislature. Of course we do have the opportunity of reopening the subject with the P. G. & E. I don't know whether we have a letter from the Edison refusing to exchange Hoover energy for Shasta, delivered to their system through the P. G. & E. system.

I don't know whether we have a letter to that effect in our files, but they did tell us definitely in the conference that we held with them that they wouldn't do it because they couldn't afford to sacrifice any of the Hoover energy because it was being used strictly for firming purposes.

In connection with that, Senator, I might make this statement. We have also been advised by the city that any interchange energy or any energy furnished by the Bureau of Power and Light would be delivered to us at steam plant rates. The steam rate, plus the Hoover rate—that is, the increase of steam over the Hoover rate—plus the increment of charge that the Edison might make in attempting to make an exchange through the city would give us an interchange cost of energy at this point in excess of the cost of energy quoted by the Arizona Power Authority.

Senator MALONE. What was the cost they finally added up for you?

Mr. BUEHLER. They didn't. We added it up ourselves and I think it ran around 6½ or 7 mills, or 8 mills delivered here.

Senator MALONE. That would be Shasta power?

Mr. BUEHLER. Yes. When we started negotiating with our lessees for 6½ million of firm energy from Arizona, they turned us down. The cost was too high.

Senator MALONE. They turned you down on the Arizona power?

Mr. BUEHLER. Yes, the lessees did. They weren't interested in any 6½- or 7-mill power from Arizona, even though it was firm on a 10-year period.

When we started looking at the picture, if we can't sell Arizona power to them firm at a cheaper rate than we can deliver Shasta, we kind of lost a little interest, at least in attempting to sell Shasta power in this part of the country.

DUPLICATING POWER LINES

Senator MALONE. That is what I wanted to find out, is the interest in it. I think that makes it entirely clear. And in that regard, over a period of years, whenever a bill was presented to build a transmission line by the Government, they would say that there was no need to build a transmission line wherever they have one because they would deliver the Government power wherever it was to be delivered and to that theory I agreed, because certainly you don't want the Government duplicating a transmission line held by a private company or a public company, or any other company.

Then they testified that there was no need for a steam plant at Tracy. I am very familiar with all of these arguments. They wanted to firm the Shasta power, and they testified that there was no need for a steam plant at Tracy, Calif., to firm the Shasta power, because they had all the steam power necessary, or the auxiliary necessary, to firm the power.

Therefore, there was no need for a Government appropriation for a steam plant at Tracy, to which I agree.

However, they have made it rather plain that they will not deliver it, according to your statement, and they will not firm the power except at some excessive cost, and would not use their transmission lines to bring it up here.

I think your statement is very clear, that the commission and the users here would rather depend on Arizona and California power and try to firm it in some way. I can see your point. I am only interested in finding out what the interest is.

Mr. BUEHLER. I might just say that there is, in my opinion, an additional cost involved in firming that energy. And even though the Edison Co. agreed to enter into some sort of agreement for interchange, they would naturally expect an increment charge of some sort.

The city, if it passed through the city of Los Angeles system, have already advised us that any exchange would have to take the steamplant rate, and when you add them up you will find that it costs far in excess of the cost of energy that we might get from Arizona.

Senator MALONE. I am familiar with the attitude that they take at first on everything.

In 1947 or 1948 I brought my committee to Las Vegas, because the Colorado River Commission was then buying power at about 5 or 5½ mills a kilowatt-hour from the Southern California Edison and the Bureau of Power and Light, that they were delivering it to them at 2 mills at the time at the switchboard 10 miles away and it was our power.

We had not applied for all of our power.

Right away after that, the commission did apply for the power because we brought the evidence to light.

Naturally they didn't need to charge 5½ mills a killowatt-hour for 2-mill power for 10 miles of transmission, but they did and the commission was paying it.

What was that great organization that handled all the business of the Government in the States, War Assets and Defense Plants Corporation? They testified they didn't even know Nevada had any power.

Well, we have made quite a lot of improvement, I think, in the commission and in the general attitude since then.

You have withdrawn all of your power and you are doing the best you can with it. In my personal opinion, it wouldn't be as hard to get the power from Shasta Dam as it was to get the original withdrawal from Hoover Dam power when we first got it in 1929 or 1930, but that is only my personal opinion.

I am only interested in your opinion here.

Mr. BUEHLER. May I make another statement, Senator Malone?

Senator MALONE. Go ahead.

Mr. BUEHLER. The Colorado River Commission, of course, is very much interested in Shasta power. I think that the one area that is very well located for Shasta power would be the northern part of the State, because it is in the economic zone of service.

However, I think that in the course of time, disregarding cost, that Shasta power may be used in this part of the State, providing we had

it tied up in such a way as the Upper Basin States of 7,500,000 acre-feet of water for the next thousand years.

We wouldn't have to have the Shasta power tied up that long, but if we could at least be assured that we could take Shasta power over a period of 10 years, I think that the situation in this part of the country might well develop to the point where we would love to have it, but presently we only have, what is it, a 1-year contract for Shasta power? It does not give us time enough to work out the problem for this section because in the next 3 or 4 years we feel reasonably sure we can meet the demands of our basic lessees from Arizona at a cheaper rate than we could bring Shasta in here but at the end of a 5- or 6- or 10-year period, if we have a contract that permits us to withdraw it, even though the cost might be higher.

It seems to me that we should make an attempt to have that power allocated to us for at least a 10-year period, or 15 or 20 years, rather than have them say, they will give us a year and a half and if we don't use it we will lose it.

Senator MALONE. Were you present at the hearing with the attorney from Washington and Carson sat there and outlined what it would be possible to do?

Mr. BUEHLER. Yes, I was at the hearing but I don't remember the details.

Senator MALONE. Do you have a transcript of the hearing? I think it would be a good idea to review it, because this is what they said representing the Bureau of Reclamation.

You have 1 year to make arrangements—the contract is very definite—to make arrangements for transmission when and if you can use it, but the contract very definitely specifies that you could take it and they would deliver it to you when they could deliver it.

You will find that very definite language if you get that contract.

Mr. BUEHLER. It isn't in our present contract.

Senator MALONE. No, but you are given a year. You had a year to get an arrangement for transmission when and if you wanted to use it. You now have another year, which is slipping away very rapidly, and the contract would definitely include, as you will find if you look up the statement of Harvey MacPhail, that you can take the power back at that time.

If you don't take it when they have it, you would then have to wait until they had a surplus of power.

They are not through developing the river yet. Folsom Dam power is coming in next year.

Mr. BUEHLER. I remember that.

Senator MALONE. In other words, you have more than a year to take it.

Mr. BUEHLER. I remember that meeting.

Senator MALONE. I am not trying to tell you what would be in the contract, and I am not trying to tell you to take the power, but I am trying to tell you that you are going to lose it again in a very short time unless something is done about it, and if you are in good shape down here nothing probably will be done about it.

That definitely was in the statement of Harvey MacPhail. He is still the Assistant Commissioner of Reclamation and would probably help you write the contract.

You don't have a contract now. What you have is a year to make a contract, and a year to get the facilities to bring it over if and when you take it.

Mr. BUEHLER. In that event, I think we should at least try to get a contract.

I recall the conference in Carson City, but it was prior to the time that a shortage of power was developed in this part of the State, and I understood that the Shasta energy was to be used exclusively in the northern part of the State.

At that same meeting, if I remember correctly, Harvey MacPhail said that the Bureau of Reclamation would build a line between Red Butte and Reno, and possibly another line from Sacramento. Those lines were to carry the entire allocation of Shasta energy for the State of Nevada, but it was in the northern part of the State.

Senator MALONE. You are mixed up in your conference because they have been trying to do that for 7 or 8 years, and that is where the power company testified they would transmit the power, wherever it was necessary, wherever the Bureau said it ought to be, or wherever the contract called for.

They have a transmission line that is now bringing about 40,000 kilowatts to northwestern Nevada. The only thing is they have indicated they would rather own the power themselves than to have Nevada own it, and there the argument ceased, nobody arguing on the Nevada side.

It is my personal opinion, not based on any promise, but based on the promise to reexplore it that you can get more than 33,000 kilowatts of power.

I mean, you might even get your full 90,000, but you will not get it unless you want it, and I definitely remember that the circumstances were that if you would take the power now you could get it, but if you couldn't take it until a certain future time, you would have to wait until they could deliver it to you, until they had it to deliver.

RESERVOIR OF ENERGY

Mr. BUEHLER. Senator, I would like to ask a question at this point.

If the Colorado River Commission made further attempts to have an interchange of Shasta made for Hoover through the P. G. & E., Edison, and possibly the city, and we were turned down, would you think that we could still secure a contract, a 10-, 15-, or 20-year contract so that we could draw that energy if and when we need it?

We might even want to build a transmission line of our own from the northern part of the State down here. It is feasible but whether it is practical or not I don't know, but we would like to secure that energy over a long period of time, that is, we have a reservoir of energy to draw on if and when we are in a position to get it down here.

Senator MALONE. I can only say this to you, Jack. If the Colorado River Commission had taken the same attitude toward Hoover Dam power that it is now taking toward Shasta, you wouldn't even be on the Commission. There wouldn't be any power here.

We just simply walked out on the line and Fred was the Governor, and the chairman of the Finance Committee told me to bid on the power, which I did.

The Governor flew to Washington when Mr. Whatever-his-name-was—was Secretary of the Interior, and was tramping me pretty hard as State engineer. He had hobnail tracks all over me by that time, and he said to Mr. Wilbur, "We are ready to call a special session of legislature and underwrite the power," and that is the way we got the power.

They won't let you build a transmission line, but you have to show you are going to get this power one way or another, and before they let you start a line they will turn a switch and you will have it.

That is the way these things work, but you can't do it by just arguing.

Mr. CAHLAN. I would not like to have the record show that the Colorado River Commission is not interested in this power, Senator. I think it is a matter that should be discussed with you as a Senator from Nevada rather than as chairman of this committee.

I don't think the committee is interested in whether we are going to get Shasta power or not. The committee is interested in the statement made by this commission that we feel that we can and will get the power any time these people who are going to use it are willing to sign a firm contract.

That is the position of the Commission to your committee. We can and will get the power if titanium is going to up their output another 30 tons. We have every reason to believe—and Mr. Martindale carried it out in his statement—that the power is available in this area for that purpose in a defense setup.

So far as your committee is concerned, that is the position of the Colorado River Commission. So far as the Shasta power is concerned, I think that is a matter that the Commission would like to take up with the Senator from Nevada outside of this meeting.

Senator MALONE. I think you are correct on that.

If we have no further suggestions, I want to thank not only the Colorado River Commission, but the representatives of industry and the Federal Government, the Bureau of Mines, the Mining Department of the Department of Interior, and others who have furnished us information.

Mr. Smith, do you have anything further to add?

FURTHER TESTIMONY OF ROLLIN SMITH, PLANT MANAGER, TITANIUM METALS CORPORATION OF AMERICA

Mr. SMITH. Senator Malone, in order to complete the record somewhat with regard to Titanium Metals Corporation of America's position, I would like to point out that the surplus power available from Arizona contracted for by the Colorado River Commission is available in two forms.

The first of these of interest to our corporation, is surplus power available on an if and when basis, as discussed previously.

There is also a block of power available which is firm for certain months of the year and carries a capacity charge which makes its total cost of no interest to our corporation.

Firm power at a premium price might be of interest if it were available for 12 months, which is not the case.

Senator Malone, in connection with your request that the Stauffer Chemical Co. furnish the unit requirement of chlorine, hydrochloride

acid, and caustic soda for Titanium Metals, I have talked to the Stauffer people and we would both prefer that these figures come from the Titanium Metals Corp.

Senator, I think it would be helpful for the Titanium Metals Corporation of America to recapitulate our program and present status somewhat in the manner that our competitors have done previously this afternoon.

The Titanium Metals Corp. was formed by the National Lead Co. and the Allegheny Ludlum Steel Co., and these corporations are joint owners of the new company.

The National Lead Co., prior to the formation of the Metals Corp., had two small sponge pilot operations, and later operated a third pilot operation.

The Allegheny Ludlum Steel Co. was conducting pilot operations in melting, alloying, and fabrication.

The Metals Corp. obtained a letter of intent from the General Services Administration for the construction of a plant, having a capacity of 3,600 tons of titanium per year to be located on property acquired by the National Lead Co. from the Basic Magnesium Products at Henderson, Nev.

The first production from this unit was obtained in October 1951, and was at about a 1-ton-per-day rate. The equipment which was to be provided for chlorinating titanium ore, known as the chlorinator constructed of inconel arrived a year and a half late, due to the strategic nature of the material used in its construction.

Our company modified existing equipment in Henderson to carry out this operation. The occurrences of this nature, including improvisations and revisions, necessarily delayed our overall program.

Titanium Metals Corp is the only completely integrated titanium operation, to the best of my knowledge. At Henderson we produce titanium ingots directly from rutile ore and with the concurrent recovery of magnesium and chlorine by electrolysis of the byproduct, magnesium chloride.

This integrated operation is far more complex than that of any other present operator. The corporation, through the facilities of its coowner, Allegheny Ludlum, fabricates all of these ingots into finished products.

To the best of my knowledge, the Titanium Metals Corporation of America is presently the largest producer of titanium sponge. It is the largest producer of titanium ingots and the largest producer of finished titanium shapes.

Our melting and alloying capacity, like that of our competitors, is considerably in excess of the sponge available. As mentioned by General Metzger, we have at one of Allegheny Ludlum's plants a scrap recovery program which is well along in its development, and apparently very successful.

I would like to point out in closing that the investment required for a plant to produce sponge is very large compared to the investment required to enter into the melting and alloying.

That is all I have.

Senator MALONE. The hearing will now be closed, at 6:45 o'clock.

(Whereupon, at 6:45 p. m., the hearing in the above-entitled matter was recessed to reconvene in Los Angeles, Calif., November 3, 1953.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

TUESDAY, NOVEMBER 3, 1953

UNITED STATES SENATE,
SPECIAL SUBCOMMITTEE ON MINERALS, MATERIALS AND FUELS ECONOMICS, OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Los Angeles, Calif.

The subcommittee met, pursuant to call, at 10 a. m., in the Foy Room, Statler Hotel, Los Angeles, Calif., Senator George W. Malone, Nevada, chairman of the subcommittee, presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee); Senator James Murray, Montana.

Also present: Jerome S. Alderman, counsel to the subcommittee.

Senator MALONE. The subcommittee will be in order.

Let the record show that Senator Murray of the subcommittee is present. Senator Barrett of Wyoming and Senator Clements of Kentucky are unable to be here, and Senator Millikin is in Europe.

Senate Resolution 143 has charged the Senate Committee on Interior and Insular Affairs, or any duly authorized subcommittee thereof, first, to make a full and complete investigation and study of the accessibility of critical raw materials to the United States during a time of war; and, second, to study and recommend methods of encouraging developments to assure the availability of supplies of such critical raw materials adequate for the expanding economy and the security of the United States.

It is the first time a Senate committee has been charged with that particular job.

There are about 77 minerals, materials, and fuels on the strategic and critcal list. (See list on p. 331.)

Senator MALONE. This particular hearing has been called to determine two things: First, the value of the new metal—some call it the wonder metal—titanium—in the manufacturing field, and chiefly, of course, in the production of military and commercial airplanes. The titanium metal is not new in itself. Engineers have known about it for many years. But it has only become practical since the demand for higher and higher speeds of airplanes and higher heat resistant alloys.

Second, some people believe that there has been two different approaches to injure, if not destroy, the United States. One was a political approach when we recognized Communist Russia in 1934 without any safeguards. The second approach was economic, which also started in 1934, with the passage of the 1934 Trade Agree-

ments Act. That act put the United States, with its high wage and living standard, in direct competition with the sweatshop labor production in Europe and Asia, and, as a result, we have become dependent on offshore areas across one or both oceans for many of the materials and minerals and fuels without which we cannot fight a war. There are many military strategists who believe it will be extremely difficult, if not impossible, to keep the lines of transportation open in time of war, and that is a further duty of the committee to determine as near as possible. We intend to hear military strategists, as to the transportation lines which can be kept open in time of war.

Now, with respect to titanium, we have two production sources at the present time, Titanium Corp. in Henderson, Nev., with a 10-ton-a-day contract. Du Pont in New Jersey has a 10-ton-per-day contract. Evidence shows that Titanium is producing about 4 tons per day. I am not able to say exactly the status of the Du Pont production because we have not heard from them as yet. But we will hear their testimony very soon in Washington. I am informed Du Pont is not producing 10 tons per day, but only about 3 or 4 tons per day, about the same as Titanium Corp.

This titanium metal then has many qualifications for use in moving equipment, some of which uses are classified. It is about twice as strong as aluminum per unit per pound. It doesn't corrode even under sea water, and the alloyed metal will stand the higher speeds, so it has become very necessary, how necessary the committee is trying to determine. That is the reason the committee is hearing testimony from practical businessmen actually turning out the equipment. They can't operate on theory; they have to produce equipment according to specifications.

Next, today we are getting the raw material, rutile, largely from Australia. We have all of the raw material, ilmenite, in the United States and Canada, if it is properly developed.

The committee is interested in seeing that we do not have to depend on offshore areas across either ocean for the raw material for titanium in wartime. If it is advantageous to trade with a nation across the ocean in peacetime, that is fine. But we should also be developed to the point where we could immediately become self-sufficient in case of war.

In addition to the producers whom we are hearing here today, I have specifically invited Gen. Kern Metzger, Chief, Production Resources Division, Air Materiel Command, Wright Airfield, Dayton, Ohio, to be present at the hearings. Wright Field is the outstanding experimental field in the United States.

We have Mr. Douglas, of the Douglas Aircraft Co., this morning.

The demand for this metal is dependent, of course, to a certain extent upon its cost. Sponge is about $5 a pound now. The rolled material is about $15 per pound. I believe that as the demand increases and the process is perfected so that manufacturers can depend on greater production, the use will increase and the cost will decrease, which of course will increase its use. We are at the point now where, you might say, magnesium and aluminum were at one time. I can't tell you how expensive the first aluminum was, but it was maybe $50 a pound. But it finally became very reasonable in price because there was a great demand.

This committee held hearings in Seattle about a month and a half ago with the engineers and producers of minerals, moved to Henderson, Nev., and heard the Titanium Corp. and other corporations which produce the various ingredients which go into the production of titanium, and we heard the mining engineers of the Bureau of Mines. I have known these men from the Bureau for 25 years. I have worked with them in my own engineering business. I know who they are and I know their capabilities. If you had heard their testimony of what we can do if we use our heads in the United States and in the Western Hemisphere to become self-sufficient, you would be surprised.

Mr. Blue, titanium expert from the Bureau of Mines in Washington, is here. Let the record show that he is present.

Now, Mr. Douglas, I know your time is valuable and limited. We appreciate your being here this morning, and I want to say to you that the committee only wants to do one thing: We want to be helpful. I can say to you also that, with over 25 years in the engineering business and working with Government departments, I know that there is a certain reticence among businessmen in making recommendations, because sometimes they can injure their own future, as contractors for the Government. But we believe that the committee, in its report to the main committee and then to the Senate, can help get across the importance of the lack of titanium production. We hope to find out what the real demand would be if titanium were available, both for military planes and for commercial planes.

I have been personally familiar with your work for many years. You started the hard way and apparently were able to withstand shocks. If you have anything of a classified nature that you think we should know, we will arrange to hear it in executive, or closed session.

What the committee would like to know—I am sure I speak for the entire committee; Senator Murray is here and will have some questions of his own perhaps—is this:

What is your experience in the use of this new metal, titanium? What is the present demand; that is to say, what are you doing with it now; and what would your demand or requirements be if you knew you could get all you desired of a readily usable quality. You know more about it than anyone else. You are in the business of making the planes.

STATEMENTS OF DONALD DOUGLAS, PRESIDENT, DOUGLAS AIRCRAFT, AND F. T. WOOD, CHIEF MATERIALS PROCESS ENGINEER, DOUGLAS AIRCRAFT, SANTA MONICA, CALIF.

Mr. DOUGLAS. Senator Malone, may I state that it is a very constructive thing for your committee to be doing this sort of a thing. I deem it a great privilege to be able to tell what little I may know about this titanium.

I have Mr. Wood, one of the engineers, here. He can answer more specifically than I can some of the technical questions if you choose to ask him.

Senator MALONE. He looks good and tough. I took a look at him when you brought him in.

Mr. DOUGLAS. I will say this: That there is no question that titanium must be produced in greater quantities, and I think that if it is

produced in greater quantities, greater use will be made of it, and the price will come down, as it does in most things when we do increase the quantity of our production.

But, despite the fact that titanium is still a rather expensive metal, we are now using it very importantly. I might say that the biggest use we made of it is that which is now being done in the production of our new civil transport, the DC–7, and we didn't start that under a Government airplane contract, where you might say they could afford to pay any price. We are putting it on a commercial airplane where it is competitive with others who are not presently using it, and we are making it pay even at the present price.

Senator MALONE. That is very interesting.

Mr. DOUGLAS. I think it is. You see, that was straight commercial competition. We went to that metal in the DC–7 because it saved important weight.

Senator MALONE. If I might ask a question—I don't want to interrupt your line of thought—if you had available the amount of this material you needed, even at the present price, what would be the approximate displacement in weight, that is, the additional payload?

Mr. DOUGLAS. On that particular airplane, the DC–7, we saved about 200 pounds by the use of it.

Senator MURRAY. How many?

Mr. DOUGLAS. Two hundred pounds per airplane. Two hundred pounds in an airplane is a very valuable thing, because we reckon rather broadly that a pound in an airplane is worth $40.

Senator MALONE. One pound is worth $40?

Mr. DOUGLAS. We have saved $8,000 for the customers, we say.

Senator MALONE. Additional payload?

Mr. DOUGLAS. That is right. Now, in that particular airplane, even if it were more readily available at lower prices, we probably would not at this time use more. I will try to explain what I mean there.

We have got to develop more techniques of using it, and we are doing that right along. We have got to have available, as time goes on, alloys that are not fully developed now. Those will come. When different segments of industry use them, why, we will get the alloys and apply them in more places than we are now. As of now, with the type of titanium sheet that is available, we probably could not economically use more on that particular airplane.

To give you a broad picture of what we feel about it, Mr. Wood has prepared some general pictures. I will just hit the high spot on it. That is this: That as of now we are using from 1 to 3 percent of the weight of our airframe in titanium. Projecting what we are planning on our engineering, both for military and civil aircraft, it would appear to us that by 1957 we would probably be using something in excess of 20 percent of the structural weight of the airplane in titanium.

Senator MALONE. Please explain the phrase, structural weight?

Mr. DOUGLAS. We call the structural weight of the airplane the weight of the airplane less the engines and the landing gear and the radio and guns, if any, and things of that character.

Senator MALONE. The frame and the covering?

Mr. DOUGLAS. That is right.

One of the other reasons, of course, that this increase appears to be certain to us by 1957 is this:

That we are going to higher speeds. I don't think that is a security matter. Everyone knows that. As we hit higher speeds, particularly supersonic speeds, we start to run into the matter of heating of the frame by the high speed air. It is at that point, of course, that a material like titanium doesn't only become worth while but it becomes necessary probably to use.

Senator MALONE. Something that is light enough to displace aluminum and still stand the speed?

Mr. DOUGLAS. Strong enough to maintain its strength with higher than normal temperatures, you see, as we get into these supersonic temperatures.

Senator MALONE. How high would these temperatures get?

Mr. DOUGLAS. I can't tell you offhand, but they are something that you have to worry about, as you get into supersonic speeds.

This, in a broad way, is the way we look at it. We are certain that titanium now is at the stage aluminum once was, and that it is going to develop. Our industry will probably be the first industry pressing for more production at lower prices, but I think, just as happened in aluminum, other industries will come in for the use of it. Now, the greatest use of aluminum and alloys was aircraft, but I think that is not the case any longer. We know what has happened.

Senator MALONE. It went into general use as the price came down.

Mr. DOUGLAS. Beg pardon?

Senator MALONE. It went into general use as the price came down.

Mr. DOUGLAS. That is right. Aluminum alloys went into general use after we had made the initial purchases and the Aluminum Co., and others had perfected alloys. That took time too, just as it does in titanium, and brought the price down.

Senator MALONE. Someone suggested you might speak a little louder. It is hard for them to hear you. But the information you are giving us is the important thing, no matter how you speak.

NEED MORE PRODUCTION

Mr. DOUGLAS. That, in a broad way, is the way I see it. I think it is a very important thing. I don't think there is any question but what in our national interest we should provide in every way we can for increased production. I am certain that when production does increase that there will be a natural growth to more use. I am certain that as those things happen the price will come down.

As far as military aviation is concerned, however, as we get into these high speeds, we are going to increase its use at any price, I feel. It is that important.

Senator MALONE. In other words, the price is not a factor when you come to military planes at higher speeds?

Mr. DOUGLAS. It is not a factor in our design, but we want to save the Government money.

Senator MALONE. What I meant, you would have to use it regardless of cost, but it is the engineers' and the laboratories' problem to work out the price.

Mr. DOUGLAS. That is right.

Senator MALONE. We would like to know as much as you can tell us and think it is expedient to tell us of your requirements at this time, that is, in tons annually or any factor that you might use.

Mr. DOUGLAS. I am sorry, Senator, that I don't have the figures for our whole industry. I believe those are available, however.

Senator MALONE. You just have them——

Mr. DOUGLAS. I only have the figures pertaining to our own company.

Senator MALONE. You know what you are doing. Maybe the percentage——

Mr. DOUGLAS. You can multiply—I would say it would not be too far off—if it were multiplied by 6 to 8 times for the aircraft industry, something in that neighborhood.

Senator MALONE. Six to eight times.

Mr. DOUGLAS. So you can take these figures and multiply them in some fashion like that, and I don't think you would be far off.

In the year of 1953 we will use about 5 tons; 1954, about 13 tons.

Senator MALONE. You are talking about total figures?

Mr. DOUGLAS. Yes. In 1955, about 22 tons.

Mr. WOOD. The figures Mr. Douglas has given you are for present contracts and firm usage.

Senator MALONE. In commercial planes?

Mr. WOOD. No, not necessarily. It is everything. But there is a lot of proposed usage on models that are in the design stage now that could possibly run these figures higher.

Senator MALONE. The second question I was going to ask you is: If it were available just like aluminum or stainless steel, and all you had to do was to design the planes, then what would be the demand?

Mr. DOUGLAS. Well, we would have to—I am sorry I haven't done so—we would have to take our total weight of airplanes that we expect to produce in 1957 and take about a fifth of that. I am sorry that I don't have that figure. But it would appear to me to be quite an appreciable amount. If we are using, you see, by 1955, as I just stated, 22 tons, which is a big part of your present production, by 1957 I would certainly think that we would be using something in excess of a hundred tons, which is more than your present production.

Senator MALONE. A hundred tons?

Mr. DOUGLAS. In that year. You take 100 tons and maybe multiply it by 8; you have 800. Say 1,000 tons would be a conservative figure.

Senator MALONE. That is only for the airframes?

Mr. DOUGLAS. Yes.

Mr. WOOD. It doesn't include the engine, by the way, which uses titanium.

Mr. DOUGLAS. Or the accessories.

Senator MALONE. You are talking about the frames.

Mr. DOUGLAS. Nothing but the airframe.

Senator MALONE. I understand from your testimony that from the drafting board to the plane in the air might be 2 or 3 years or more. Is that correct?

Mr. DOUGLAS. Well, the flow time in producing an experimental model is about 2 years. Then it is usually close to 4 years before you get much production.

Senator MALONE. Before you really go into production after the drafting?

Mr. DOUGLAS. Design, that is right.

Senator MALONE. Then it can only be taken off the drafting board in accordance with its availability?

Mr. DOUGLAS. Well, we do have to look ahead, and we have to make a guess that it will be available at the time of design.

Senator MALONE. In the engines, including the engines and all the accessories, what would be your annual use?

Mr. DOUGLAS. I don't know, but it would certainly be, I would think, at least as much as we use——

Mr. WOOD. Maybe 30 or 40 percent, at the most.

Senator MALONE. Thirty or 40 percent of the weight of the plane?

Mr. WOOD. That is right.

Senator MALONE. Altogether?

Mr. WOOD. Yes.

Senator MALONE. Let us assume we had reached the point where supplies were sufficient. What would be the approximate tonnage for your use alone?

Mr. WOOD. It is difficult to tell, because it depends on the size of the airplane and the number of them you produce in a given year. We don't know them, don't know the size, and don't know how many we would produce. Any figure we give you is a guess.

Mr. DOUGLAS. Just assuming the defense program would go along about what we understand is planned.

Senator MALONE. If the defense plans for new bombers were to be stepped up suddenly, your use would be multiplied many times?

Mr. DOUGLAS. That is right.

Mr. WOOD. The weight of an airframe will vary from as little, in a small fighter-type aircraft, as maybe 7,000 or 8,000 pounds, to close to 100,000 pounds. When you start talking about the quantity of them that are produced, it varies the figure just fantastically.

Senator MALONE. If you had a hundred-thousand-pound plane, that was 20 percent?

Mr. DOUGLAS. 20,000 pounds; 10 tons, you see.

Mr. WOOD. Just one plane.

Senator MALONE. If you had 3,000 of those, you are getting into titanium.

Mr. DOUGLAS. Yes, indeed you are.

Senator MALONE. If you are getting into, say, 3,000 of those big planes, at that rate it would be 30,000 tons in a year.

IN CASE OF WAR

Mr. DOUGLAS. It just appears to me, Senator, if we are going to design aircraft, as it appears to me, that will increase in proportion of titanium, we have got to think what we are going to do should we get into war.

Senator MALONE. We want to approach that.

Mr. DOUGLAS. The figures I gave you were just assuming what is ahead of us less war. If you are going to have war, your guess is as good as mine, probably.

Senator MALONE. Not as good as yours. One of the ideas I have had all along—and I am not a military strategist, but I have been in two of these wars, many people whom I talked to do not think you are going to fight the First World War over again or even the second. You are going under the sea and in the air in the next one.

It has always seemed to me, after coming home in 1919 from the first one, that the way to keep out of the war is to be ready to win it, and if everybody else knows as much as you do about your preparation, then perhaps that is the way to keep out of a war.

So I still think that you yourself would know more than anyone else, not in the number of planes perhaps, but how to meet specifications. That has been another mystery to me, as to why—and we have an expert here in the general, and I don't want to get into his field—the military designs the details on a plane. Perhaps it would be better if they would tell what they wanted the plane to do, and let you design it.

Mr. DOUGLAS. That is actually the case. We develop a general specification to get the type of a weapon that the Air Force needs. Under the present concept, that is the way we are doing.

Senator MALONE. Now, in the commercial planes, or even in the military planes, what effect would the price have on the use? Suppose, instead of $5 a pound for sponge, it was testified at Henderson that there is a possibility of getting the price down to three and two and a half dollars. Say the sponge came down to $3 and the cost of rolling was cut down proportionately, what effect would that have on the use?

Mr. DOUGLAS. Well, I am not able to make a specific forecast on that, Senator, but there is no question it will increase it. How much I am at a loss to guess.

Senator MALONE. Well, you said that the price is not much of a deterrent to use of titanium even in a commercial plane because of the additional payload which could be carried if titanium were used.

Mr. DOUGLAS. Well, the place where we used it, we were not replacing an aluminum alloy; we were replacing steel, because there it was used largely in the engine cells. We would have had to use stainless steel or something of that character if we had not had titanium. It was a replacement of stainless steel rather than a replacement of aluminum alloy at that point.

Let's take and consider the wing. The alloy would have to be very cheap to make a worthwhile substitution for an aluminum alloy in the wing skin, other than in the neighborhood of your high heat.

Senator MALONE. In these lower speed planes, you do not have to use titanium, and therefore the price will have to come down quite a bit to be an economical and feasible substitute for aluminum?

Mr. DOUGLAS. That is right.

Senator MALONE. Aren't you beginning to use some high-speed planes for regular commercial transportation?

Mr. DOUGLAS. The next period is a jet transport, but that is not high speed enough to involve any heating from the air of any consequence. That will be the next era. That will be the supersonic era. That would be, as far as civilian aviation is concerned, I am afraid, quite some years away.

Senator MALONE. What would be the speed of this new jet plane you are talking about?

Mr. DOUGLAS. Your jet transport will be an airplane of something like 550 miles an hour cruising.

Senator MALONE. What would the price of titanium have to be in order to substitute it in your landing gear and other parts of the plane, heavy parts?

Mr. DOUGLAS. That may come about, but we haven't seen it as being worth while as yet.

Senator MALONE. The price would have to come down to do that?

Mr. DOUGLAS. Too, we have got to learn to use it, Senator. It takes us a little while to find ways of forming it, ways where it pays one way or another to use it in place of something else.

Senator MALONE. Another thing I understand is that it is almost impossible to reclaim the scrap, and the scrap is wasted. It is not like steel, where you can just throw the scrap in a pile and use it to produce new metal. It is almost impossible to reclaim titanium scrap. That is true, isn't it?

Mr. WOOD. Yes; that is generally true, although I understand one company has a method by which they hope to be able to reclaim it.

Senator MALONE. Senator Murray?

Senator MURRAY. No; I am listening with great interest. I think the information I am getting here is new to me, and I am very glad that I am able to attend this hearing. I understand the problem; I think it is very, very important. I want to congratulate the witness on his very fine statement, very interesting statement; it is very valuable to us on the committee and will be when we come to make our report.

Mr. DOUGLAS. I think the most important thing, if I may be permitted to say it at this time, is that if we go to design fighting planes around his material, then we have got to have a capacity available should we get into war.

If you want to make an assumption—I am trying to think out loud here if I may—that in a war we might want to build 50,000 planes a year; if you want to guess that those constructions of those airplanes might weigh 50,000 pounds average, you can do the arithmetic. I can't do it mentally. Take the product of 50,000 times 50,000. Take a fifth of that. That could be, 1957, 1960, if we are in war at that time.

Senator MALONE. That is a very valuable statement, Mr. Douglas, and I know you are a very conservative man in your estimates; you are not conservative in your design; you never have been. You have always been ahead of the times.

The imperfections that are still prevalent, that is, the lack of uniformity of the metal, still holds you back to a certain extent, too?

Mr. DOUGLAS. Could I let Mr. Wood give you that?

Mr. WOOD. Yes; however, the quality of the material has improved enormously in the last 2 years.

Senator MALONE. We are probably in about the same place with titanium as we were with synthetic rubber before World War II, when we knew we could make it but at first we couldn't make the quality that we needed. Now they can make the quality you need, and I am advised that in many uses that you wouldn't really have to use any natural rubber, although it is better if you did. So we have perfected that process.

Now, do you have any doubt that, as the demand increases, and additional contracts are let perhaps to additional companies, production process of the metal will be perfected?

Mr. WOOD. No. I think that with time we will get exactly what we want out of it. I think, however, Senator Malone, that you really shouldn't try to compare it to something else. It is an entirely new

metal, and it has certain inherent, basic qualities of its own that make it desirable to use, regardless of the price and the availability and that type of thing. There are other places where it would never fit.

Senator MALONE. Mr. Wood, as a technician in this business—and I wasn't joking when I said you look good and tough to me; I have been in the engineering business 30 years; I don't look very tough, but you have to be to stay in the business—would you in your own words give us some real information on the technical end of it, as you look at it.

Mr. WOOD. Do you mean why we would use it in places?

Senator MALONE. And what is holding you back now, what you think needs to be done, and the stages that have to be reached before you could just turn your drafting people loose on the drafting board and forget about the availability of it?

USAGE DEPENDENT ON MANY FACTORS

Mr. WOOD. Generally speaking, I think our usage is dependent upon the price, the availability, and our know-how in fabricating it and handling it, good service experience with parts that we have already built, and obviously to be able to get the engineering properties out of the material that we have to have.

Now, titanium at the present time, for a modern-day transport airplane, does not compete favorably with aluminum. It is not strong enough on a strength-weight ratio basis to actually displace aluminum in the airplane at the present time. It is being substituted for stainless steel, primarily, and the two properties of titanium that seem to appeal to us the most at the present time are its heat resistance and its corrosion resistance and its ability to retain its strength at elevated temperatures. Again, though, titanium in its present form, in its alloys and the commercially pure grades that are available to us at the present time, doesn't compete favorably with stainless steel at temperatures above a thousand degrees Fahrenheit.

Even on a combustion engine such as the ones we use on our DC–6's and 7's, we use a lot of stainless steel there, and in some cases the stainless steel is operating at temperatures above a thousand degrees, and this material will not replace it at the present time.

Senator MALONE. What about the alloys?

Mr. WOOD. Well, there are several alloys on the market. Every producer has an almost limitless supply of them, it seems. But, Senator Malone, there are very few people who are actually using them. In our particular company we are making practically no use of the alloys at the present time because we don't have a design requirement necessitating its use.

Senator MALONE. You are still in the stage of titanium that you were with aluminum many years ago?

Mr. WOOD. That is right.

Senator MALONE. You knew it was good, but you didn't know just what to do with it.

Mr. WOOD. That is right.

Senator MALONE. Well, that is the committee's interest in it, because, according to Mr. Douglas' testimony, which merely corroborates other testimony that titanium is absolutely necessary for certain uses. Then there are certain people in the Government charged with letting

contracts. They have their own future to look out for, and sometimes, if they make a mistake it is not good, and it could be that if the Senate of the United States knows enough about titanium, it can encourage whatever chances it thinks the Government should take through its contracts, as, for example, clauses in the contract with the Titanium Corp. and with Du Pont, and I believe in this new contract for 15 tons per day with the Crane Co. of Chicago. They are not in production, not even settled down as to where they are going to produce, but these clauses take care of obsolescence of equipment due to changes in the process, and of course every one hopes that somebody will work out a continuous process or electrolytic process or some other process to cheapen the cost of titanium. We understand there are companies making great progress in that regard.

But, as Senator Murray said, the position of this committee in its recommendations to the main committee and then to the Senate, can be influenced greatly by knowing just what could be done with titanium if you could just throw the book away and start the design and know you are going to get sufficient amounts of titanium.

But we are down here now at the roots. If you can't use it, then there is no use manufacturing it. If you could use titanium, if it were actually available in usable quantity and quality, we want to help because we are in the position that we can talk back to pretty near everyone if we think we are right.

I would like to call a 5-minute recess for the benefit of the reporter, and then we will finish up.

(Recess.)

IMPORTANCE OF AIR POWER

Senator MALONE. Mr. Douglas, do you have any further statement, generally speaking, on this important subject? I heard you say a while ago on television that you thought Russia was making titanium. I will ask you—I had it in mind before the recess—if any potential enemy of this country had the metal and was using it in warplanes, what could we afford to pay to have titanium in our military aircraft?

Mr. DOUGLAS. We would probably be able to pay any price if it was necessary for us to have a superior aircraft to the potential enemy.

Senator MALONE. I am going to ask you a general question, because I have heard of you for so many years—I know there are 2 or 3 of you who are competing for the lead in the production of planes for both military and commercial purposes. Some of us have an idea that if we have the necessary aircraft, big bombers that can fly several thousand miles and drop a load going 700 or 800 miles an hour and come back, that we are in no danger of being defeated in a war and as a matter of fact, we would be in little danger of being involved in a war.

I would like to have your general opinion of what we could do if the production of titanium were sufficient to be used in the manufacture of these planes.

Mr. DOUGLAS. My personal view, Senator, is that if we have a superior Air Force we have no reason to fear ever losing a war. It has always appeared to me that if Britain kept the people of the continent from invading them for several thousand years with only 20 miles of water, we surely ought to be able to do just as well with a

real Air Force with 2,000 miles of water between us and the potential enemy.

Senator MALONE. In other words, if we were to keep in the lead with respect to the speed and range of our bombers and fighters, there is no nation that would trouble us in the Western Hemisphere, and perhaps any part of Europe or Asia we are going to protect could be done through the control of the air?

Mr. DOUGLAS. I am certain of that, Senator.

Senator MURRAY. I understand that some scientific commission a short time ago made the statement that an atomic bombing raid on the United States, if properly directed, could result in the destruction of a third of the industrial production of the United States and kill 15 million people. That, of course, is on the assumption that we would not be ready to defend or to prevent such a raid.

Have you any suggestion to make with reference to any such possibility, the effect of raid on this country?

Mr. DOUGLAS. I am no expert on the matter. I suppose that at its worst that might occur, but I personally don't believe it could be quite that bad.

Senator MURRAY. That is all.

Senator MALONE. Naturally, we are getting into a field strange to both of us. We got into the radar and guided missiles and all. But the control of the air is the first consideration in any area we want to control, is it not, in your opinion?

Mr. DOUGLAS. Absolutely.

Senator MALONE. I think you have covered this in general, but as far as the committee is concerned—feeling very certain that with 3 or 4 companies besides the ones who actually have contracts developing new formulas of continuous processes, as well as the batch processes in the production of titanium, working on that they have now, and the Kroll—we are still groping for the price range that would make titanium more generally used in commercial planes.

I agree with you—and I am sure the committee agrees with you—that under existing world conditions, we must have military planes at any cost. Of course, we are interested in getting the price down, but we feel the higher the production the lower the cost, just as you have outlined in aluminum and magnesium fields. The price of titanium would have some effect on its use, not only in commercial planes, but also in military aircraft.

Is there any further information you could give us in that field?

Mr. DOUGLAS. Well, no, Senator, I don't believe. We are using it now on our new airplane about as widely as we could, no matter what the price was.

On our next airplane——

Senator MALONE. It is on the drafting board now, perhaps?

MUST SAVE WEIGHT

Mr. DOUGLAS. In the next airplane, the jet airplane, which is about to come to the drafting board stage, we will plan to use more, in spite of the fact that the price is rather high now.

Senator MALONE. In other words, the price is not the deterrent that might be supposed; when you get around to using it, it is because it is a necessity?

Mr. DOUGLAS. That is right. We pay almost any price to save weight, whether it is a military airplane or a civil airplane.

Senator MALONE. What was the estimate as to what you would save for each pound or hundred pounds in weight saved?

Mr. DOUGLAS. Just a rough estimate, we say that every pound we save—put into payload for the operator—is worth something like $40.

Senator MALONE. That means for the life of the plane?

Mr. DOUGLAS. That is right, availability of carrying that much more pay cargo.

Senator MALONE. That is a tremendous thing.

Now, the commercial jet that will come off the drafting board next, that is still under supersonic speeds?

Mr. DOUGLAS. The heating, due to the atmosphere, at high speeds does not come into the problem——

Senator MALONE. In the event we make the progress in the materials necessary for it, and other experiments work out—it would not be too long until you reach the supersonic speeds, would it?

Mr. DOUGLAS. That is quite possible.

Senator MALONE. Then you would have to use this heat-resistant material in many other parts of the aircraft, such as the sheathing of the plane?

Mr. DOUGLAS. Use what is necessary of the material at that time.

Senator MALONE. If titanium were available, very soon it would amount to about 20 percent of the weight of the plane?

Mr. DOUGLAS. By 1957; that is correct.

Senator MALONE. Of course, it goes without saying that as the quality improves, that is to say, the usability and uniformity of the material, so that it rolls uniform and works uniform, then of course the use increases?

Mr. DOUGLAS. That is right, sir.

Senator MALONE. That does hold you back somewhat now?

Mr. DOUGLAS. Somewhat; yes.

Senator MALONE. Because of the nonuniform rolling qualities?

Mr. DOUGLAS. We have to feel our way, and we have to have some time in operation in different parts with this material to be sure to see how it stands up in time, a matter of fatigue.

Senator MALONE. I think one of the most important things you have said here this morning is that as titanium production increases and improves, the price will come down, and the use will be increased.

You look for that to take place?

Mr. DOUGLAS. I would think so, because now you see farmers using corrugated aluminum for barn roofs. That would have been unthinkable in the beginning.

It doesn't seem so hard to imagine that if titanium was cheap enough it would make a more satisfactory material because of its noncorrosive qualities.

Senator MALONE. And stronger?

Mr. DOUGLAS. Yes.

Senator MALONE. Weight?

Mr. DOUGLAS. That is right.

Senator MALONE. The first aluminum went into planes, did it not?

Mr. DOUGLAS. Yes.

Senator MALONE. In other words, aluminum was used in planes first, but as it became more plentiful and cheaper, many civilian uses increased the demand for it?

Mr. DOUGLAS. That is right. Civilian demand now for aluminum alloys is greater than the demand by planes.

Senator MALONE. Much greater, and that is for cooking utensils and various other things.

Mr. DOUGLAS. Construction materials of all sorts.

Senator MALONE. Do you think titanium might follow the same route?

Mr. DOUGLAS. I should think it very well might.

Senator MALONE. I think we have covered the territory, barring the classified material, here.

Off the record.

(Discussion off the record.)

Senator MALONE. On the record.

We will make this a part of your testimony at this point.

Titanium usage, general

Present	1 to 3 percent of airframe weight (weight of airframe less engines, landing gear, radio, etc.).
1954 through 1956	2 to 8 percent of airframe weight.
1957 on	22.5 percent (maximum) of airframe weight.

Total present firm usage:

1953	9,430 pounds per year.
1954	26, 941 pounds per year.
1955	42,831 pounds per year.
1956 (½ year)	19,453 pounds per year.

Our general use of titanium depends upon obtaining good mechanical properties, reasonable cost of material and fabricating techniques, good service life and availability.

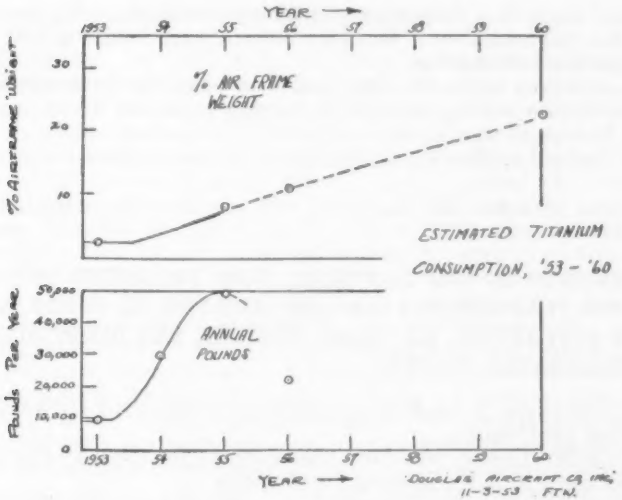
Usage by division

Santa Monica:

DC–7	528 pounds per airframe, 2.5 percent of airframe weight.	
DC–8	528 pounds per airframe, 8–11 percent of airframe weight.	
1953	9,280 pounds per year.	DC–7 only.
1954	26,400 pounds per year.	
1955	26,400 pounds per year.	

El Segundo (models and rates classified):

1953	150 pounds per year.
1954	450 pounds per year.
1955 on	15,000 pounds per year.



Senator MALONE. Mr. Douglas, I had no set line of questioning and I am sure Senator Murray did not. We think you are one of the outstanding manufacturers and pioneers in the airplane business, and I can speak for the committee. We appreciate your appearance very much, and I would like to have it understood that any further information you think would be of value to the committee, that you would furnish it to the committee. All you need to do is address it to either the chairman or any member of the committee, Senate Office Building. If the material is classified, we will treat it accordingly. If it is not classified, we will be very happy to place it in the public record. Would you do that for us?

Mr. DOUGLAS. Yes, sir, we will be glad to.

Senator MALONE. I am reluctant to let you go, but I know you have to go. I have been looking forward to your appearance here because, as I previously said—and I know that I am speaking for Senator Murray—you are pioneering in this field, and we feel that a Senate committee working under official resolution, Resolution 143, directing us to do this work, can take chances that perhaps a Government official couldn't take, or even a producer who is under contract could not take. But we are willing to take the chances. I am sure I am speaking for the members of the committee. We have an idea that we are right in the field, and therefore we might accelerate the necessary production, which would result in a lower price so that it could be used more generally in planes. I can say to you that the primary concern to those on the Senate floor, in addition to the high taxes that everyone is worrying about, is this matter of a potential war. Many of us have the feeling that if we get ourselves in a position to win any kind of war, we will not have such a war. And any time we can't win it, we are liable to have it.

I don't know that there are any military strategists on the committee or in the full committee. But they certainly are listening and trying to digest the information.

I want to say again we thank you very much for your appearance, and we will be looking forward to hearing from you if you have anything further to state to us.

Mr. DOUGLAS. Thank you, Senator. It was a pleasure to be with you.

Senator MALONE. Mr. Lanphier, will you identify yourself for the record?

STATEMENTS OF TOM LANPHIER, VICE PRESIDENT FOR LONG-RANGE PLANNING FOR CONVAIR; AND LOWELL GORDY, ASSISTANT SUPERVISOR, MATERIAL CONTROL, SAN DIEGO DIVISION, CONSOLIDATED VULTEE

Mr. LANPHIER. I am Tom Lanphier, vice president for long-range planning for Convair.

This is Mr. Gordy, who buys the titanium for the major programs that we use it in at the moment for Convair.

Senator MALONE. Mr. Lanphier, you attended our hearing in Henderson last month?

Mr. LANPHIER. Yes, sir; last winter sometime, yes.

Senator MALONE. You are familiar, then, with the objectives of the committee?

Mr. LANPHIER. Yes, sir.

Senator MALONE. The committee is interested primarily—and you are familiar with the Senate resolution that the committee should determine the availability of the necessary materials, minerals, and fuels in wartime.

The first step, then, is to determine the amounts of these materials and their source. There is another angle, of course, that we will follow through, and that is what lines of transportation can be kept open in wartime. Many believe we will have more trouble than ever in the next war in keeping any lines of transportation open across the major oceans.

We are now receiving the raw material, rutile, primarily from Australia, for no good reason except it was available there, and you are familiar with the fact that the ilmenite, at least, is available in this Nation and Canada. There is also some rutile in the Florida beaches.

But you are in the business of manufacturing airplanes and airplane parts, so your contribution to this committee would principally be in the field of the use of the material.

So the general question to you would be the same as the one addressed to Mr. Douglas, who just finished his testimony, as to what you are actually using at this time, what would be your need in total pounds or tons of the material if titanium were available, and you did not have to worry about the supply any more than you do about aluminum, stainless steel, or any other common metal. So if you would just give us any information or statement on this subject, the committee will appreciate it.

NOT USED COMMERCIALLY

Mr. LANPHIER. To begin with, we build commercial airliners, but we don't at the moment use titanium in our commercial program. We have a number of military programs with the Air Force and the Navy, and we do use at the moment titanium in those programs, and we plan to use a considerable amount more on a graduating scale in the future.

Particularly, we use it, at the risk of repeating what Mr. Douglas said——

Senator MALONE. In that category, you go right ahead with your own story, because we are interested in hearing several of the companies, and then the committee can study the record and add it up.

Mr. LANPHIER. He certainly is as expert a source as you can find for the commercial aspect of aviation; no question about it.

I think, in the next 4 or 5 years, our company, among others, will certainly have an optimum amount of experience in the use of this metal for two purposes: At the moment we are using it to save weight, as he indicated he is in the commercial airplanes. We are planning to use it and are already beginning to use it in our supersonic programs, because of its faculty for resistance of heat. The planes are going to be going so fast that we will need to use the metal on the leading edges, wherever friction is likely to occur at these high speeds; also use it internally, around the engine, for heat-resistant purposes that he mentioned.

Under existing contracts with the services, we have need for and are using this year about 55,000 pounds. Next year we will use about 72,000 pounds; and in 1955 we will use about 13,000 pounds. This again is under firm contracts.

I will give you some planning figures for the amount of the metal we will need, both pure and alloy, for the extension of these porgrams in which we are now fairly well started for the Government. The total figure then for 1955 will be somewhere around 773,000 pounds; for 1956, be on the order of two million-plus pounds or a thousand tons. Beyond that, our plans don't go at the moment.

Senator MALONE. I don't want to interrupt your line of thought, but your information is very helpful to the committee, not surprising, but informative.

The increased use beyond the figure—when you say you have not gone any further than that—depends on what, on the availability and workability of the material?

Mr. LANPHIER. Well, sir, no; I just didn't go any further in this set of figures, because relatively in the firm planning we do, we end at that period of time into the future. There isn't any question but what if we have gotten that far with these several programs which are the components of these totals, that the programs concerned are going to either at least prevail or continue on upward in magnitude, and there will be an even greater requirement in 1957 and 1958. It will peak off in 1957 and drop back down possibly in 1958. But about then we may begin to use it in some other programs that haven't yet been contracted for, but will be in about 2 years; also in the high-speed area.

Senator MALONE. You heard Mr. Douglas testify that his testimony—and presumably yours—only covers a prewar period. If

suddenly the airplane industry were asked to produce like they were asked to produce during World War II, that would be a different situation, would it not?

Mr. LANPHIER. You mean under the circumstances of atomic war?

Senator MALONE. If you were asked to produce, say 40,000, 50,000, 60,000 planes a year, you would be into real production. That would make a different story?

Mr. LANPHIER. Oh, indeed; excuse me. This is on what you call a 127-wing objective. Let's just say 127 wings that our programs are a part of here. The objective is somewhere in 1956, 1957, 1958.

Senator MALONE. It is a peacetime preparation?

FEWER PLANES FOR ATOMIC WARFARE

Mr. LANPHIER. That is right. I would say that, as compared with—if it is a fair comparison—during the last war we got up to some 350 groups in the Air Force; it isn't a fair comparison because the atomic weapons now don't require the number of airplanes to deliver the equivalent amount of bang that the World War II——

Senator MURRAY. With atomic warfare you wouldn't need so many thousands of planes?

Mr. LANPHIER. That is right; more complex, faster, higher flying, but not as many in number. Equally as tough to produce, however; probably more so, that is, tougher to produce 5 of the atomic bearing systems with the speeds and altitudes required than it was, say, to produce 200, 300 of the World War II type airplanes because of the complexities involved, electronics.

Senator MALONE. What can you tell us, then, beyond 1956, as to volume demand for this material?

Mr. LANPHIER. I could only estimate, because I would be guessing at how many more airplanes the Government would buy from us. I would say it would be at least as much as this for this one company and for airframes alone. I am now talking about airplanes; exclusive of engines. This is for airframes alone and for missile frames.

Senator MALONE. Suppose the volume of production was stepped up so that the price range would probably come down, and the metal was available for any use you wanted to make of it, what then would be the use?

Mr. LANPHIER. Well, let's say in 1956 we are using, say, a thousand tons, which comprises what percentage of the airframe; 5 percent, 3 percent?

Mr. GORDY. I would say about 10.

Mr. LANPHIER. This is a very short period of time between 1953 and 1956, so we couldn't actually in these programs I am talking about use any more than we are presently using because we would have to redesign the airplanes to accommodate it. I can't answer that question other than academically.

Senator MALONE. That is correct, but we are trying to see beyond that.

Mr. LANPHIER. Beyond that; say we were building an equivalent airplane progressively better some 3 or 4 years later. What would you say by 1960 of a supersonic airplane; you could actually, sensibly use how much titanium for; that is our military kinds of airplanes?

Mr. GORDY. If there was no limitation to cost?

Mr. LANPHIER. That is what he is talking about. He is assuming that the dollar barrier is minimizing the volume.

Senator MALONE. I am assuming the metal is available; you don't have to worry about the availability, regardless of cost.

Mr. GORDY. Military?

Mr. LANPHIER. Yes.

Mr. GORDY. About 40 percent, right around in there.

Mr. LANPHIER. Between now and 1960. On the airplanes we are now involved on, we have committed ourselves to a design.

Senator MALONE. That is true.

Mr. GORDY. That is considering the fact that the metal is uniform, it is easily formable, and the dollar value is down and readily available.

Senator MALONE. And somebody will buy the planes?

Mr. GORDY. Yes; and that the performance is within titanium range.

Senator MALONE. Let me ask this in a different way: Suppose we had reached 3 years ago the stage we now have reached, and you had your plans——

Mr. GORDY. If we had known this 3 years ago, we would have designed approximately 3 times as much titanium into the airplane as we now have.

Senator MALONE. What I am trying to reach—and I am sure Senator Murray will agree with me—we know you are the tough hard-boiled producers. You have to produce; you have to pay the help. There isn't any use of your going off the deep end, saying you would like to do this and that; that is done in Washington—too much of it.

But we came out here to see you because we know you know how to use this material. The committee is not going to learn how to make planes; it is not going to learn how to produce titanium; it has been through the plants; it knows the methods—but if the committee can encourage the contracts that you worry about, if we think it is necessary to increase the production and to encourage other companies, as well as the ones that are now in the production, to get into this field; in 1 year or 2 years from now some continuous process should be developed, or electrolytic process or a sodium process or some other process that cheapens the metal and makes it available—is all the titanium you need available now at $20 a pound.

Mr. LANPHIER. That is right.

Senator MALONE. So if the committee is convinced, from the volume of testimony we receive from you actual producers of the planes and the actual producers of the metal, that all this is possible, it is just a question of somebody taking a chance—if we believe when we get all this testimony that the Government should take that chance we should try to get the same Government encouragement for titanium as was given in the synthetic rubber field, and build the plants. If the synthetic rubber program hadn't been a success, the Government would have lost the money. It was a success and saved the country.

If we can get this volume started that you need, and you don't have to worry about volume at all—all you have to do is your drafting job and put everything in it that you want, then what would we be able to do? This is your end of it; 40 percent or 50 percent, including the engines and the landing gear and the frame, and if you get up around supersonic speeds, it would be the covering?

Mr. LANPHIER. We don't know that much about it.

Senator MALONE. You don't know that much about it?

Mr. LANPHIER. No, sir.

Senator MALONE. Go just as far as you know about it, if it were available.

Mr. LANPHIER. Well, he has given you the answer. I would say of the part of the airplane we build, the airframe, we could build the airplanes—we know something about it for the next 4 or 5 years—if we had our "gimmies" right now, maybe 30 percent.

Senator MALONE. You could use 40 percent with any new design?

Mr. LANPHIER. No; I meant if we had our "gimmies" in the first place.

DEPENDING ON GOVERNMENT

Senator MALONE. If you had it 3 years ago. Let's talk now about what you would be doing 3 years from now if you knew it was going to be available in usable form; is that what you meant, 40 percent?

Mr. GORDY. Yes; around 30, 40 percent, in there. It is a nebulous figure. But we figure that 3 times as much titanium as we have in the airplane now at this time—we feel we can put 3 times as much into it if it was readily available and usable. I think we can say that we are depending upon the Government to go in the titanium industry, at least, make it available, because our projected usage is so far in excess of the present capacity of the titanium industry, we are definitely going on faith that it will be there.

Senator MALONE. You are taking——

Mr. GORDY. Using the titanium, in designing it into the airplane.

Senator MALONE. Right now you are taking all the chances that you can afford to take in business?

Mr. LANPHIER. So is the Government with us.

Mr. GORDY. Yes.

Mr. LANPHIER. I would assume on a well-calculated basis.

Senator MALONE. That is what we want to find out, because——

Mr. LANPHIER. We are in bad trouble if, for instance, the Air Force hasn't had such assurance from the Government that there will be a certain measure of titanium within which our allotment falls in the next 3 or 4 years. I am sure there must be at least some solid thought given to the amounts that we are talking about here, plus the ones you will hear from, from other companies, being surely available to us somehow or other in the next 3 or 4 years.

If your committee can establish the point that titanium is the useful metal it is in the air end of the defense industry, you can have a very much greater Naval Air Force and Air Force in the next 4 or 5 years than you will otherwise have, because you will get considerably greater performance in terms of lighter airplanes and planes that can stand together in the heat at high speeds. No question about it.

Senator MALONE. You are familiar with the fact that the Government has already advanced about $30 million to 2 plants; $15 million I believe has been advanced to the Titanium Corp. in Henderson, and that company has reached a little short of 4 tons per day. They have a 10-ton-per-day contract. They gave us some evidence that they were continually increasing this production. The Du Pont Corp. had $15 million available. We have not heard them as yet, and I don't know

whether the Government has actually advanced all of the $15 million, but it is available.

Now, there are companies that are talking about taking contracts without any Government money, just like companies are now willing to take over a synthetic rubber plant and run it at a profit. Some of us believe—there is where some difference of opinion comes in in Congress—that when titanium or any other material, reaches the point at which private industry can make a profit at a reasonable price, then the Government probably would lose interest in the production because the demand, the price, and the profit would take care of its production.

But before you reach that, somebody has to take a chance; and while Senator Murray and I are only 2 of the 96 Senators—I am sure he agrees with me that we are willing to take the chance of throwing whatever weight we have to increasing this production, and let the Government guarantee in this contract, as they now do, have a paragraph that takes care of obsolescence in equipment due to laboratory advancements and inventions and so on.

We are using the Kroll process now. It is a batch process. If, as some of us think, they come up with an electrolytic process or some other process that lessens the cost of production and makes obsolescent several million dollars worth of equipment, the Government is going to lose that much money. But that is what we are here for.

So forgetting about the availability of titanium; assuming it is just like aluminum or stainless steel; you could take it right off the drafting board and start tomorrow—how long would it take you to substitute titanium and how much titanium would you be using in 3 or 4 years? I really believe, as one member of the committee, that we are going to have such production. It is possible. And I think it is a bottleneck that this committee can help to break. So that is the value of your testimony: What you can do. You are the ones who pay the help and have to depend on contracts. I know it is hard to forget that because you have been worried about it so much.

Mr. LANPHIER. Well, you have, as you are well aware, some sizable "ifs" in your premise.

Senator MALONE. As they had in aluminum 50 years ago.

CONSISTENCY OF MATERIAL

Mr. LANPHIER. Consistency of the material itself is one of the things in our particular use. I heard Mr. Douglas say their scrap on pure metal is down to what—10 percent on commercial use. Our estimates of the sort of scrap that we are going to have to deal with for the next few years for our military airplanes, wherein we use 50 percent pure and 50 percent alloy, run 100 percent at first, then get down to 50 percent a little bit later. So we are going to have a fairly extravagant use of it in bulk because it is not yet of a quality.

Senator MALONE. Uniform?

Mr. LANPHIER. Yes, sir. So I repeat: That is a big "if" in the next 3 or 4 years, isn't it?

Senator MALONE. That is right. No doubt, the number of experiments that are being run, the number of responsible companies working on it, and the number of contracts let, and the future demand are going to have a lot to do with the speed of perfection.

Mr. LANPHIER. What you just said is what happened since we last convened with you, which is 9 months or a year ago. It is a great deal advanced now. In fact, we plan to use it now for more extensively in 9 or 10 months than we did just less than a year ago. No question about it; as people begin to catch on to the value of the thing to the defense industry, I am sure that private enterprise, as well as subsidized programs, which are essential, are going to make strides that we can't contemplate now.

Even if we knew titanium would be available in usable form in 3 or 4 years I still say we wouldn't be using more than 30, 40 percent of that part of the system——

Senator MALONE. That doesn't include the engine or the landing gear or any other part?

Mr. LANPHIER. That is right. I am including the landing gear in that total. I am talking about the airframes as opposed to the engine, particularly. Those are two major elements in which you would use titanium.

Mr. GORDY. Mr. Lanphier mentioned we have a higher spoilage factor on military airplanes. That may be due to the fact that we are using it on much more complicated parts, possibly, than on commercial applications.

And also I just got back from a 5-week tour of the entire industry myself, all of our suppliers, expediting deliveries of titanium, and they have, in going through their development programs, many applications that the general industry is not aware of right now that we might utilize in future designs; for one example, the casting and extrusion work that they are having very promising results with. That would naturally increase our scope of thinking in the use of titanium.

Senator MALONE. You mean because the extrusion process, if it were successful, would make it more workable or more plentiful?

Mr. GORDY. It would have better properties than the titanium now processed.

Senator MALONE. What companies do you refer to?

Mr. GORDY. Well——

Senator MALONE. Who are your suppliers, the ones you are talking about?

Mr. GORDY. Rem-Cru has furnished material to extrude; a number of the companies have. They have also developed casting processes which appear to be very promising. I know Kaiser Aluminum up here has extruded titanium, from what I gather, from almost every company in the business. They requested material from almost everyone.

But there was one item you mentioned here a while back about 15 tons a day that the Henderson plant is producing.

Senator MALONE. They are supposed to produce 10 tons, but they are up to about 4 tons now.

Mr. GORDY. We have to be very careful about comparing that with our total requirements, because presently, in the converting of the sponge to a finished sheet, there is quite a loss in there we have to take into consideration.

Senator MALONE. It was brought out in the testimony there that some of this material is being shipped to England. We haven't found out just how much yet. But that is not the fault of the company.

Now, it is a fact, isn't it, that it is almost impossible at present to reclaim the scrap?

Mr. LANPHIER. It is for us.

Mr. GORDY. One thing that we are very concerned with is the scrap. We have it building up now, and Rem-Cru, for example, will not take the scrap back unless it is reduced to particles three-eighths of an inch square, and it must be oil-free and in lots of, I believe it is a thousand pounds. And to meet those requirements is almost impossible.

Senator MALONE. Are they able to pay you any particular amount for it if you do produce it in that quantity and that form?

Mr. GORDY. Right now, depending upon the grade, they tell us it ranges between a dollar and a half and a dollar ninety cents a pound. I understand that the Air Force is suggesting a program whereby we take our titanium scrap, give it back to the producer, and he will in turn make us material containing that scrap, and send it back to us with a credit for the scrap, which would be presumably a higher figure than we would realize under the present method.

Senator MALONE. Did they estimate that figure?

Mr. GORDY. No; they did not commit themselves.

Senator MALONE. This scrap at $1.90 compared to the sponge at $5?

Mr. GORDY. Very generous figure.

Senator MALONE. And the rolled material at $15 a pound. Do you buy it already shaped, or do you just buy the rolled titanium sheets?

Mr. GORDY. Flat sheets, and that $15 a pound, if we can buy some flat sheet at that, we would like to know where it is, too, because that is a very low figure. We average, in the lower gages right now, approximately $22 to $22.50 a pound.

Senator MALONE. Well, the reason I have used the $15 is because someone used it as an estimate. I want that understood, as merely my repeating someone else's estimate.

Mr. GORDY. That is quite possible in the case of billet stock from which you hog forgings or titanium fittings. That runs $15 to $19 a pound in that price range.

Senator MALONE. Isn't the experience in the whole metal field—of course, you are a comparatively young man, and that is the kind of men who are in this business—that whenever you are paying $22 a pound for anything in the metal business, isn't there plenty of room for improvement, if we get the volume and get it so it is usable? That is what we are trying to find out.

Mr. GORDY. Definitely, definitely. Here is another thing: In talking with the titanium producers, they are not sure themselves how much this metal should cost. They can't actually price it out to what it is costing them to produce it; they tell us——

Mr. LANPHIER. We don't know that on airplanes in the early part either when we start.

Mr. GORDY. Because titanium, in the case of Republic Steel or these largest companies, is a very minor portion of their production.

Senator MALONE. Of course. But what we are trying to do is to find out what the annual demand might be if the workability and the supply were made available at a somewhat lower figure. We know what Mr. Douglas said is perfectly true. It is a question of the hen and the egg again.

Mr. LANPHIER. You are trying to find out what percentage. Then you can multiply the percentage per unit times the number the military people tell you they actually plan to buy.

Senator MALONE. Right. What is holding us up? Is it the workability of it, the loss of the scrap, the price or what?

Mr. LANPHIER. I would say, just from a completely lay point of view——

Senator MALONE. You are the one who makes the plane.

UNCERTAINTY

Mr. LANPHIER. We don't know too much about the elements involved. But I would say that it is a reflection of what he says. There is an uncertainty, or has been in the industry that produces the stuff as to just what requirement, even as you are uncertain, as to what requirement there might be, particularly militarily, for it; where the initial development funds are going to come in terms of millions of dollars; and we haven't been sure until the last 6 or 8 months just how much on a minimum basis we want to use. It is a question on the part of the educators, on the part which is progressing pretty fast. In another year they would know a lot better.

Senator MALONE. We have General Kern Metzger here, who is at the head of the Wright Airfield, and he has already appeared before the committee. He is here to do that again. But even among the high officials of the national defense of the United States, there is a difference of opinion. We all know that. Many of us are of the opinion—I am sure that I am not the only one—that this next war is going to be a little different from World War I that we fought in the trenches. I was in that one. Then I had a good look at this Second one out in the South Seas, Alaska, and everywhere. But this one is going to be different from any of them.

It is like the story goes: Before the Civil War a couple of young men were talking; they were friends, 1 from the North and 1 from the South.

Finally the one from the North said to the southerner, "Cy, what are you going to do when we get in the war? There are too many of us; we have the industry."

Cy says, "We can whip you with cornstalks."

Well, the war came along in 6 or 7 years. They met again, walking on canes. They had both been hurt pretty bad.

The northerner said, "I thought you said you could whip us with cornstalks."

Cy looked kind of thoughtful for a minute, and he said, "We could have, but they wouldn't fight with cornstalks." [Laughter.]

We don't think you are going to fight in the trenches or ships too far away; we think you are going to fight in the air and——

Mr. LANPHIER. We were well prepared to win the last war in the air, but we may be very ill prepared to win the next war.

Senator MALONE. This time you are going to fly faster and farther than the other fellow.

We are groping for the answer. If we had it, we wouldn't be here.

NEED STANDARDIZED PROGRAM

Mr. GORDY. You asked a little while ago what would help in furthering the titanium industry, and I think one thing would be a standardization program, namely, specifications. Everybody has his own specification. The Air Force has its specification. Every producer has his specification. Every user has his specification, and no two of them are the same.

Mr. LANPHIER. They don't jibe and nobody meets them. He is right.

Mr. GORDY. There is another point: They are running this on a job-shop basis now. They get an order for a certain amount, and they make that number of sheets, run it through their shop, the most expensive way of running something.

If some central agency could say, "All right, you produce 2,000 sheets of this material, .032," they would run it through as one job, with better control and uniformity and everything else, and price.

Senator MALONE. It might sometime reach the point that steel has reached, where any company can produce any grade. But this has not reached that yet, in your opinion?

Mr. GORDY. That is right.

Another standardization point is in the alloys that are used. They will come up with any alloy you want if you order 800 pounds, about 800 pounds. They will come up with any alloy you want to use in your airplane.

Senator MALONE. But there is no uniformity all the way through so you can just look at the catalog and say you want so much of a certain grade; there is no such thing yet?

Mr. GORDY. You order it from Titanium Metals Corp., and you can't blindly go to another company and order a standard alloy. It is different.

Senator MALONE. Two orders from the same company would get you two different kinds?

Mr. GORDY. Yes; same order from the same company. In commercially pure sheets we are receiving, we are testing, depending upon the number that we get in, about 1 out of every 5; and upward of 1 every 20 sheets. On alloy sheets we are testing every single sheet we receive in order to use the material, classifying it into two different categories, the formable and the nonformable, to hold down our scrap and utilize every bit of material that is shipped to us.

Senator MALONE. What percentage, in the long run, if you know—or just estimate—has to be rejected because of the nonuniform qualities?

Mr. GORDY. Well, the rejections run all the way from receiving—rejection on physical properties to damage from fabrication. On commercially pure or alloy, there is a world of difference between the two.

Senator MALONE. Let's get the question narrowed down. In other words, on the matter of specifications and workability, without regard to any other elements, what percentage has to be rejected because they are just not workable?

Mr. GORDY. I would say right now about 20 percent.

Senator MALONE. Then that is nothing more than scrap?

Mr. GORDY. That is nothing more than scrap?

Senator MALONE. Then what is the percentage of scrap of the workable material? What is the loss?

Mr. GORDY. If it is workable there shouldn't be too much loss.

Senator MALONE. How much, if it is workable and the sheets are workable? You have to roll your sheets——

Mr. GORDY. The planned manufacturing variants?

Senator MALONE. No, I mean, when you receive the sheets, what size are these sheets?

Mr. GORDY. 36 by 96.

Senator MALONE. You stamp your shapes and cut them out; what is just the natural, ordinary waste, scrap material for this operation?

Mr. GORDY. After you cut out your pieces?

Senator MALONE. That is right, considering no loss for nonworkability or nonuniformity?

Mr. GORDY. That depends a lot on the type of part that you have on the sheet.

Senator MALONE. I mean just in the general statement.

Mr. GORDY. It would be a very nebulous one, but I would say that there is a loss of around 30 percent.

Senator MALONE. About 30 percent, and that is added to 20 percent?

Mr. GORDY. Yes.

Senator MALONE. So you really are out 50 percent?

Mr. GORDY. That is right.

MUST WHIP SCRAP PROBLEM

Senator MALONE. That makes whipping this scrap problem very important.

Mr. GORDY. Definitely, definitely.

Senator MALONE. If you had this scrap in position so that, like steel scrap, all you had to do was sell it to a junkman or put it on the train and ship it in to the nearest mill, you would really have something.

Mr. GORDY. Right now we are having to stockpile it. We sold some to a junk dealer a while ago because we couldn't sell it to anyone else for $1.25 a pound, and he hasn't been able to get rid of it himself yet. He hasn't found anybody else to take it off his hands.

Senator MALONE. That's the last you will sell to him.

Mr. GORDY. We may buy it back for 50 cents. [Laughter.]

Senator MALONE. I know there are several companies working on this reclamation problem. Do you have any idea about how close business is to whipping the scrap problem?

Mr. GORDY. No, sir.

Senator MALONE. Senator Murray?

Senator MURRAY. I am fully in accord with your questions, Mr. Chairman. I think that if we get some valuable information here, that will be very helpful to us in trying to develop——

Mr. LANPHIER. If you can cause more titanium to be made, we can use it; no question about it.

Senator MURRAY. I think it is very important that we do that, because of the danger of war coming on, and we are poorly prepared at the present time.

Mr. LANPHIER. Yes, sir.

Senator MURRAY. We are not in a very good situation right now, so it is vitally important that we go forward with this study and try to develop this thing as rapidly as possible.

Mr. LANPHIER. I would think so, sir.

Mr. GORDY. It is the generally considered opinion that one of the big deterrents to further advances in airplanes and their performance is materials that will stand up under these higher performances.

Senator MURRAY. This question of standardization is vitally important.

Mr. LANPHIER. Yes, standardize the material, the production of it so you can build it cheaper and have more of it, make certain that the quality is better, and then develop some reclamation program for that that has proven qualitatively insufficient.

Senator MURRAY. What are the sorts of defects that may show up in the titanium as it is introduced into the plane? What defects could possibly be discovered?

Mr. GORDY. Right now, that we are experiencing right now?

Senator MURRAY. Yes.

Mr. GORDY. We have our biggest problem on alloy sheet. We will form a long angle, and it will crack at different points along the line, but the rest of it may be all right, so we are going through a thorough inspection process every piece that we produce, to be certain that it is structurally sound.

Senator MURRAY. Is that a very difficult task, to determine its soundness?

Mr. GORDY. Definitely.

Senator MURRAY. I remember in the war, producing a cable they were able to run through a machine and defects in it.

Mr. GORDY. Titanium is a very new metal. New inspection methods are in process of development now. The titanium industry realizes that the physical testing of steel which they are applying to titanium does not give a true picture, as is borne out by forming characteristics.

You can bend a sheet one way and it is structurally sound, but you try to bend that sheet in the other direction and it will crack, just break right open during forming. Those are some of the things.

WEIGHT AND HEAT

Mr. LANPHIER. I would like to endorse one thing he said: The titanium has two general uses. (1) It saves weight; (2) its heat-resistant faculties are important.

On the one hand, the weight; it is a question of how much do you want to pay to save weight in terms of dollars and performance, if you want to use titanium. You can, in other words, get the job done with something else if you want to pay enough, or if you don't want to pay the dollar, but there is no substitute we know of, in some of these supersonic systems, for the heat-resistant qualities that it has and the weight combined.

If we don't have something like this, we are likely not to have effective supersonic fighters and bombers.

Senator MURRAY. It is that serious?

Mr. LANPHIER. Wouldn't you agree, General?

General METZGER. I testified, I believe, to that in the past.

Senator MURRAY. The chairman has pretty well covered the situation, and I am in accordance with his views on the situation. Our chairman is an engineer himself, and I think he will be very helpful to our committee when we come to study this thing and analyze it. The testimony we got this morning, I think, is very, very fine. I am very grateful to you men for coming here.

Mr. LANPHIER. You are rendering us a service, all of us.

Senator MALONE. Thank you, Senator Murray.

And I would ask you another question here: Are you now getting the titanium you need for your present construction, on time?

Mr. LANPHIER. Well, two answers to that; in one instance, I will have to answer it generally.

Senator MALONE. I want to preface this. You can let the bars down, because it is understood in Washington and elsewhere that maybe you are reticent in answering certain questions, but when a Senator asks you, that lets you out of all responsibility to anyone that has given you a contract or anything else.

Mr. GORDY. Except security.

Senator MALONE. Except the classified.

Mr. LANPHIER. I can't describe quite why I am qualifying the answer.

Senator MALONE. We are going to ask you for some classified information.

Senator MURRAY. You don't have to fall back on the fifth amendment. [Laughter]

Senator MALONE. Some of it we will ask you for confidentially.

But what I wanted to make clear to you that these people who criticize you and let contracts to you, are dependent on the money coming from the Senate, as well as the House, and therefore it is understood when we ask you a question, and it is not classified, you will answer it; and you just say "blame it"——

Mr. LANPHIER. I have forgotten the question.

In one program we are not, where we need it in bulk for weight-saving purposes. In other programs, where we need it for a combination of weight-saving and for friction-resistant purposes, we are getting it, because the Air Force is seeing to it that we are getting it instead of someone else. That is the best way I can put it. Someone else is suffering.

General METZGER. Mr. Lanphier is referring to a matter to which I testified at your last hearing, namely, that the supply of titanium is, at this point, so short that we have found it necessary to allocate on a priority-of-use basis the present available supply.

Mr. LANPHIER. Our answer is affirmative. Somebody else's might not be.

Mr. GORDY. And also we want to state that the job the Air Force has done on allocating this material has been very agreeable to Convair. We have been very well satisfied with results that have been obtained through the Air Force.

Mr. LANPHIER. We have some programs that they consider highly important, as we do. I don't know how in some instances they do it. Actually, General Metzger does it; his office does it. But it is getting done.

Senator MALONE. Do you have other questions, General? I should have asked you before.

General METZGER. No.

Senator MALONE. We lean heavily on the general.

Mr. LANPHIER. I would think so.

Senator MALONE. The committee leans heavily on the general, because we know he knows what is going on, whether he tells us all of it or not. I guess he would do that if we asked him.

I remember I went through the gaseous diffusion plant at Oak Ridge, where uranium fuel is manufactured. Somebody asked me if I wanted to know how many bombs they had. I said, "No; I might talk in my sleep."

So there are some questions we will not ask.

We do feel in this field that we can break the log jam if we are convinced, after we see all the testimony, the Government ought to go further, or there ought to be more contracts let or there ought to be more money in it. We are not afraid to do it. I am speaking for the whole committee on that feature.

Do you have any further information, either of you?

Mr. LANPHIER. No, sir.

Senator MALONE. If you have some security material you think would be helpful to the committee, I will ask you to give it to our counsel, Mr. Adlerman, and it will be kept confidential.

Mr. LANPHIER. What we actually have are our aircraft schedules, and that is a matter of—I don't know—can you keep this sort of thing?

Senator MALONE. I don't think we want that now.

Mr. LANPHIER. That is the answer to your question. Somewhere along the line, I would assume your committee will get these from the Air Force and the Navy.

Senator MALONE. We have a lock and key, but we don't want anything that would not be helpful.

Mr. LANPHIER. This is helpful, but is also security——

Senator MALONE. We can secure this. We will not ask you for any part of it at this time.

If you have no additional information for us now, I would like to say to you, as we did to Mr. Douglas, if you at any time want to communicate with the committee and have any information you think would be helpful, address the chairman or any member of it, Senate Office Building, and we will be glad to have it.

Mr. LANPHIER. It is a useful thing you are doing, gentlemen. We wish you the best of luck.

Senator MALONE. Some of us have the feeling—and I think I can speak for the committee on that field—that if any other nation, a potential enemy, is ahead of us in the construction of airplanes, military bombers or fighters, that we are gone, and we can't afford to have that happen.

Mr. LANPHIER. That is right.

Senator MALONE. So we will now recess until 2 o'clock.

(Thereupon at 12:15 p. m., a recess was taken until 2 p. m.)

AFTERNOON SESSION

(Whereupon the hearing was resumed at 2 p. m.)

Senator MALONE. The committee will be in order.

Mr. Robert Gross of Lockheed Aircraft Corp.

Mr. Gross, did you bring anyone with you?

Mr. GROSS. Yes; Mr. George Papen, my materials and processing engineer.

STATEMENTS OF ROBERT GROSS AND GEORGE PAPEN, LOCKHEED AIRCRAFT CORP., SAN DIEGO, CALIF.

Senator MALONE. Mr. Gross, I am sure you already know the objectives of the committee.

Senate Resolution 143 created a responsibility for the Interior and Insular Affairs Committee, and this subcommittee of the Interior and Insular Affairs Committee, is called the Minerals, Materials, and Fuels, Economic Subcommittee. The resolution charged this committee with determining the availability of about 77 minerals, fuels, and materials critical to the United States in wartime, and necessary for the growing economy and security of the United States.

We are hearing evidence on each one of these materials. But today we have come to Los Angeles to see you and 2 or 3 builders of planes, people who are at the grassroots, where it is not a theory about how something is going to be made. You have to make it. The committee wants to be helpful, to the producers, the fabricators and processors, and the users of titanium. We would like to know the part the Government ought to play in this new material, from the point where the plans come off the drafting board until you actually make the planes.

We think that there is a lag between the starting of the production of titanium and its availability to the producers. We know it is a new material. It is not easily adaptable, and no one is to blame at the moment, in our judgment, any more than they were when aluminum and magnesium were new, when it cost $50 a pound to get aluminum. They just didn't know too much about it, and the thing that makes it more important now is a threatened international emergency. If there were no threatened war and there were no emergency, 15, 20, or 25 years wouldn't make very much difference. It would be a matter of economics. Now it is a matter of security and economics.

So we have here, Senator Murray from Montana. He is a member of the committee.

I just want to say to you, we want to be helpful in making this material available to you actual producers. I know there are places where a man looking for contracts can't be too critical, and you are all looking for contracts, even the producers of the metal. But a Senate committee doesn't owe anybody except the taxpayers and the security of the country anything except love and kindness.

So the general question to you would be: What about this new material? How can we be helpful in what you are doing at the present time? What would you do if it were plentiful in a usable form? You know much more about it than any member of the committee, and in your own way would you just tell us about it?

Mr. GROSS. Well, thank you very much, Senator. We are glad to appear before you and give you what information we have. I did not know the exact procedure of the committee, and as a result we prepared a formal statement, which, I suppose in the interests of saving time—possibly because some of the material may be classified—I might want to file with you. Mr. Papen and I would like to refer to it.

Senator MALONE. We have plenty of time. Why don't you make a general statement, using it as a reference? Then we will accept it to appear in the record, except such material as the general might judge or you might judge should be classified.

I want to say to you that the committee proceedings are very informal. What we are looking for is information, and we do not stand on any formality at all. We just want to consult you. We know you are a busy man, so go about it in your own way.

Mr. GROSS. Perhaps I will summarize this statement and make a few generalizations referring to this paper, and then file the paper with you.

In the first place, we are generally enthusiastic about the possibilities of the material. Our investigations have convinced us that the material has inherent qualities which make its immediate exploitation in aircraft of great concern to our services, and certainly attractive to the commercial carriers. We are very concerned about the slow production development and the limited availability of metallic titanium.

The proper application of titanium will increase the range and load-carrying capacity of our transports and bombers and will increase the speed and maneuverabiilty of our fighters. However, to accomplish these objectives, production must be increased; the lag in delivery must be decreased; the quality of titanium sheet and plates must be improved; and the cost of titanium as finished parts in our aircraft has to be reduced.

We can talk for hours about it, but those four things have to be accomplished.

The importance of a metal to the aircraft makers such as ourselves depends primarily upon its possession of one or more chemical and/or physical qualities which determine its capability of meeting a specific requirement rather than upon the magnitude of its annual production or its price per unit of weight. The properties which tend to make titanium an important metal from an airframe viewpoint are its low density, high strength, corrosion resistance which is equal to or better than stainless steel, plus maintenance of strength at temperatures where aluminum alloy is no longer useful.

In the event of another war, we think the supply of metallic titanium depends solely on the effort this country is willing to put into producing it, not upon sources outside the continental limits of the United States nor on the grubbing and doling out of limited local supplies.

This metal has a specific gravity of 4.5 as compared to aluminum at 2.8 and 7.9 for stainless steel. This is a very important characteristic of titanium to the aircraft industry and from this point on we will discuss titanium in its relation to weight almost entirely.

Now, I have several tables here that bring out the weight characteristics.

Senator MALONE. Just give us you own comparison and we will accept that.

Mr. GROSS. As you know, it is a little bit heavier than aluminum. It is a little lighter than steel. It has much better heat-resisting quantities than steel in some areas. It does have workability and proc-

essing problems which we can go into if you wish. Those are definite limitations.

Senator MALONE. Would you tell us for the record, in your own words, how the strength compares to the strength of aluminum and steel?

Mr. GROSS. Well, I suppose our best table is here.

Senator MALONE. Just roughly.

TABLE 1.—*Room temperature mechanical properties of some current titanium alloys and other common airplane structural material*

Description	Tensile strength 1,000 p. s. i.	Yield strength 1,000 p. s. i.	Specific tensile strength [1]
Commercial pure titanium	80	70	485
8 percent manganese-titanium alloy sheet	120	110	701
4 percent aluminum, 4 percent manganese-titanium alloy bar and forgings	140	130	853
Aluminum alloy:			
75S–T6	77	66	763
24S–T6	66	50	660
Annealed stainless steel	75	30	263
Fully hardened stainless steel	185	165	650
Half hardened stainless steel	150	110	530
High heat-treated steel	260	208	918
Heat-treated steel	200	165	710

[1] Formula: $1{,}000 \frac{\text{pounds per square inch.}}{\text{pounds per cubic inch.}}$

Mr. GROSS. Perhaps you would like to summarize it.

Mr. PAPEN. At the normal operating condition we are under today, titanium rates—titanium alloy bar particularly rates above 75–S, rates just slightly under the high-heat-treated steel. We are talking about the 260, 280 range, not the 200,000 range.

Senator MALONE. Make that a little clearer for the record just what you mean by those figures.

Mr. PAPEN. The heat-treated steels are usually designated by their physical properties, generally the ultimate tensile strength. In this instance we are referring to aircraft steels which are heat-treated to 200,000 pounds per square inch tensile strength or 260,000 pounds per square inch tensile strength, the range being merely the allowable tolerance in tensile strength required by heat treat. Titanium then will fit somewhere between the 200,000 to 220,000 pounds per square inch range and the 260,000 to 280,000 pounds per square inch range.

Increases in aircraft speeds tend to increase temperatures on the surface of the aircraft. As these temperatures increase, titanium assumes more importance. In the sonic range we start getting into temperatures that are detrimental to aluminum structures. Temperatures above 250° will require either the use of titanium or stainless steel.

Mr. GROSS. He means 250° F.

Senator MALONE. That will be generated at supersonic speeds?

Mr. GROSS. Yes.

Mr. PAPEN. From there up to, we believe, 800° F., titanium will fill the bill. Above 800 we have to go back to stainless.

Senator MALONE. That means more weight?

Mr. PAPEN. Yes. The important issue to us is that range from, say, 250° to 800°, represented in years of development and in miles

per hour is a tremendous area in which we do not want to have to put heavy steels and stainless steels, and yet, unless we get titanium we are forced to. It is strictly a matter of weight.

Mr. GROSS. We could go much further in development sooner if we had more of this material.

Senator MALONE. We are going to divide this question of mine in two parts: If you could forget the availability and the workability of this material, and you could let your men plan to use all the titanium they wanted to on your drafting boards, and produce a plane you would like to produce, then what could you use?

Mr. GROSS. Well, I think we all have a different figure. But I believe we feel about 20 to 25 percent of the light weight of the plane.

Isn't that about our estimate?

Mr. PAPEN. Yes.

Mr. GROSS. If cost and availability were no problem, we think we could intelligently and profitably utilize about 25 percent of the weight of certain types of airplanes. I am referring principally to fighters.

Senator MALONE. Does that include the engine too?

Mr. GROSS. No; just the frame. And that would be basically the fighter-type airplanes. That would not hold for the larger types of bombers and the transports.

Senator MALONE. What percentage of the large bombers would it be, generally speaking?

Mr. GROSS. Oh, I would think not more than 5 or 10 percent. But that is a lot of pounds, of course.

Senator MALONE. Is that at the supersonic speed also for the bomber?

Mr. GROSS. I didn't think of it as such, no. I thought of it as more of the sonic range.

Mr. PAPEN. Today's airplanes could use 21 percent right now, 21 to 25.

Senator MALONE. That wouldn't include the bombers?

Mr. PAPEN. No; bombers would run 10 to 12 percent.

Senator MALONE. Not knowing anything about the business, I can speak freely. So my question might seem to you a simple question, but it all adds to the quantity of the material.

If a bomber went beyond the speed of sound and had to have this material, would that 10 to 12 percent still prevail or would it increase?

Mr. GROSS. It would increase.

Senator MALONE. How much?

Mr. GROSS. Perhaps half again, maybe, to bring it up to 15, 18 percent, possibly; would have to have more and more skinning of the airplane.

Senator MALONE. Go right ahead, Mr. Goss.

Is this a diagram?

Mr. GROSS. Yes. That has the whole story right there on that piece of paper.

Senator MALONE. There is nothing classified on this?

Mr. GROSS. I don't know.

Senator MALONE. Do you think so, General?

Mr. PAPEN. As far as I know, it is published data.

Senator MALONE. Go right ahead. We will use this if we can.

TABLE 2.—*Cost analysis, support fitting*

Description	Steel	Titanium alloy
Cost of forging stock	$0.10 per pound	$10 to $13 per pound.
Weight of rough forging	23.5 pounds	13.8 pounds.
Total cost of forging	$7.90	$325.
Cost of finished machined part	$65.90	$499.
Weight saved per part		5.9 pounds.
Cost per pound of weight saved		$83.

TABLE 3.—*Cost analysis, jet pod door*

Description	Type 302 stainless steel	Commercially pure titanium
Cost of raw material	$314.45	$1,400.00
Labor, tooling	105.82	176.98
Total cost per door	420.27	1,576.98
Weight saved per door, pounds		44
Cost per pound of weight saved		$26.30

TABLE 4.—*Cost analysis, tubing*

Description	Stainless steel	Commercially pure titanium
Cost per foot	$3	$21
Cost per airplane	18	130
Cost per pound of weight saved		35

Mr. GROSS. Well, of course, it is obvious to us all that titanium and its alloys are more costly than other engineering materials. In order to determine whether these costs can be absorbed economically, we have to review the cost currently involved in the construction and operation of our aircraft. The approximate cost per pound of airframe of a modern transport airplane is $21.60. This is the cost per pound of that portion of the total airplane weight required to perform its mission.

TABLE 5.—*Approximate cost per pound of weight empty certain civil aircraft*

Aircraft:	*Cost per pound of basic weight (weight empty)*
Viscount 700	$19.20
DC-6A	20.00
Super Constellation	21.60
Britannia	22.20
Convair 340	23.80
Comet I	24.60

To take another viewpoint, the cost per pound of disposable load is approximately $22. This represents the cost per pound of carrying capacity of the aircraft or that portion of weight which can be used in the form of fuel, cargo and/or passengers.

TABLE 6.—*Approximate cost per pound of disposable load*

Aircraft:	*Cost per pound of disposable load*
DC–6A	$18.00
Super Constellation	22.00
Britannia	22.40
Convair 340	23.80
Viscount 700	25.80

It is evident that it is the goal of every aircraft designer to obtain the maximum disposable load at the minimum weight of airframes, engines and so forth. The ratio of pounds of basic weight required to carry 1 pound of disposable load is approximately 1.13.

TABLE 7.—*Approximate basic weight in pounds required to carry 1 pound of disposable weight*

Aircraft:	*Pound*
DC–6A	0.92
Britannia	1.01
Super Constellation	1.13
Viscount 700	1.35
Convair 340	1.90

Mr. GROSS. Without going into an exhaustive study of revenues, payload costs, and so forth, it is obvious that if the disposable load can be increased by the use of titanium or its alloys, the higher cost of titanium can be justified in certain applications, even at present prices.

The extent of use will, of course, be controlled by the effect on the cost per weight empty and the cost per pound of disposable load. What effect has the cost of titanium had on its use in our civil aircraft? We believe that the present cost of titanium has held its use down to approximately 0.03 percent of empty airplane weight. If the average cost of raw material were reduced to $12 per pound, we estimate that this percentage would rise to approximately 4.5 percent, replacing approximately——

Senator MALONE. The weight of the plane?

Mr. GROSS. Yes; replacing approximately 75 percent of the stainless used. Now, if the price of titanium is reduced, ridiculously enough, to $2 a pound, a price which is competitive with stainless, the use of titanium would rise to approximately 21 percent of the airframe weight; one-half of the weight of steel.

If titanium alloys were reduced to 40 cents per pound, competitive with aluminum alloys, which I guess is impossible——

Senator MALONE. Some distance away, anyway.

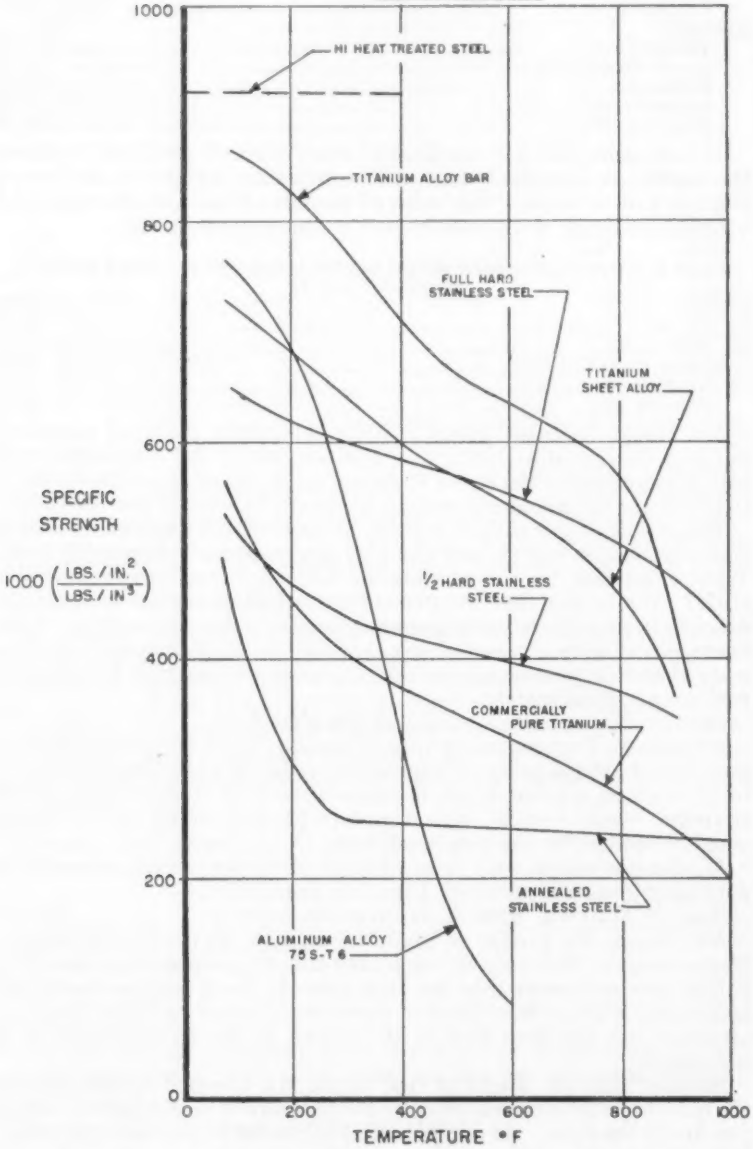
Mr. GROSS. We predict it would be used for 40 percent of the airframe weight. For military airplanes this 40 percent approximation will be reached sooner than for civil aircraft, for it will be considered well worth while to bear the cost penalties involved to insure that our airplanes are the very best in the world, as far as performance is concerned.

Senator MALONE. Right at that point, Mr. Gross, I might ask you the question: As someone has often said, there is no second best when you are in the fight. If our potential opponent in any world war has this material, then is it imperative that we have it, regardless of cost?

Mr. GROSS. I would certainly feel so; yes.

Senator MALONE. At this point the "Figure 1.—Effect of Temperature on Strength-Weight Ratio" will be included in the transcript as a part of Mr. Gross' testimony.

FIG. 1.- EFFECT OF TEMPERATURE ON STRENGTH-WEIGHT RATIO



Mr. GROSS. We cannot design for titanium unless it is available in the quantities required. The total production of titanium for 1953, we understand, has been estimated at 3,300 tons of sponge. By 1956, we understand this will grow to approximately 22,000 tons of titanium sponge. Using a factor of 60 percent for the conversion of sponge into metal, we will have approximately 4 million pounds of titanium in 1953, and 26 million pounds in 1956. Now, against this we assume must be balanced the industrial requirements.

A recent survey by the Aircraft Research and Testing Committee, of which we will have reference to, estimated an early usage of 5 million pounds of titanium, which would grow to approximately 33½ million pounds in 1956. That is commercial usage.

Senator MALONE. Let me ask you this: Whose figures are you depending upon when you say 22,000 tons will be available in a certain year—was it——

Mr. GROSS. 1956.

Senator MALONE. Where did you get those estimates?

Mr. PAPEN. They came out of the meeting at Dayton.

General METZGER. That is right.

Senator MALONE. How long ago was that estimate made?

General METZGER. 8, 10 months ago.

Senator MALONE. One of the reasons that the committee is so intensely interested in getting the entire story from the raw material to the production of planes is that 3 years ago contracts were let. On one 10-ton-per-day contract, less than 4 tons is now being produced. This is a long time. You are assuming quite a good deal when you assume you will have 22,000 tons in 1956. But that is what we would like to make sure that you have.

Mr. GROSS. It will be worse then, if these figures aren't achieved; it will be worse.

The aircraft industry's own analysis shows we are faced with an immediate shortage of approximately a million pounds, if you can except the commercial consumption. This shortage would increase to 7½ million pounds by 1956. These requirements are aircraft industry only, and do not include Ordnance and other possible users.

We are using titanium in a fighter; we are using it in a cargo plane, and we are using it in a patrol bomber, and we are thinking about using it in an experimental fighter.

Senator MALONE. You are using it now in the percentages you have already indicated?

Mr. GROSS. No, no; we are not. No, we have tables that show that. But I believe those are classified, and I have it here.

Those are the percentages, General, that we are now using, and those are what we propose to use.

Senator MALONE. We don't want any classified information in the record.

Mr. PAPEN. Those are pounds, not percentages.

Mr. GROSS. Those are actual pounds.

Senator MALONE. But as far as we can go, we would like to know what you are doing now and what you would do if you could just forget the availability like you do with stainless steel and aluminum, knowing it would be there in the quantity you want, and workable.

Mr. GROSS. Everybody talks about his own business. That is the only one we really know anything about.

Senator MALONE. That is why we came.

EXTENSIVE RESEARCH

Mr. GROSS. We think we were one of the first, if not the first, company to build and fly an airplane having titanium components used in the structure. We have been conducting extensive research and development projects. We were early in developing extrusion of titanium for aircraft shapes. This was accomplished by a joint program on an Air Force contract in cooperation with a local company here in the city. It must be recorded that the great hindrance that we found in our research was the lack or rather very slow delivery of the material.

But, to answer your direct question, in our most recent report to the Aircraft Production and Resources Agency of the Air Force, our total requirements for 1954 were reported at 62,000 pounds. That is all we are going to use for 1954.

Senator MALONE. That is all there is off the drafting board and ready to go?

Mr. GROSS. That is right. This will increase to 152,000 pounds in 1955. If the price were reduced by about 25 percent and availability assured, we would probably double these recorded quantities in a very short time.

Senator MALONE. Are you talking about the military aircraft or commercial and military?

Mr. GROSS Military.

Senator MALONE. As far as military aircraft is concerned, if it were decided that the Government could afford to go in and encourage production of a large enough volume so that the price would come down, assuming that you had the contract, then you would do what you said, as far as military aircraft is concerned?

Mr. GROSS. That is right.

Senator MALONE. What would that percentage be, if it is not classified?

Mr. GROSS. No, it isn't, I am sure.

Mr. PAPEN. 21 to 25 percent.

Mr. GROSS. But don't you feel that that is on the basis if the costs were tremendously reduced?

Senator MALONE. If the Government did not hesitate, and let you go ahead?

Mr. GROSS. I guess the answer is 21 percent.

Senator MALONE. In other words, Senator Murray and I have come this distance to get what you can do. Then we tell our story to the main committee, the full committee. The subcommittee consists of five Senators; we report to the full committee, and it reports to the Senate. But our recommendation to the full committee will depend upon the coordinated story we get.

Now, if we know what you can do, and then we have some idea maybe of what our potential enemy is going to do, it could be that the price would not be a bar to it, and that is what I would like for you to consider.

Mr. GROSS. Well, if price is no consideration and availability were assured, we feel that we could use as much as 20 to 21 percent in the light weight of our planes. That would be in our program right across the board.

Senator MALONE. At this time?

Mr. GROSS. Yes; if we confined it solely to our military planes in the class of a fighter we could get as high as a third to two-fifths, maybe 33⅓ to 35 percent, maybe even as high as 40 percent.

Senator MALONE. Does it ever go as high as 50?

Mr. GROSS. Well, I don't think we have been able to see that.

Senator MALONE. No advantage after about 40 percent?

Mr. GROSS. That is what we thought. But that is a lot; that is a tremendous amount.

Senator MALONE. I know your problem. You don't dare take anything off the drafting board that you can't go through with.

Our problem in the committee is a little different. We want to know how far we should go in pressing for increased availability, and not to hold back on account of the cost.

I mentioned synthetic rubber a time or two this morning. It didn't make any difference what the rubber cost. You couldn't get it any place else, so the cost was all right. Now, luckily, the rubber came down to compete with natural rubber. But if it hadn't, we'd still have to make it.

Mr. GROSS. Well, do we feel that it is actually feasible; is it possible to get the cost down?

Senator MALONE. We don't know; that is why we are getting testimony. Of course, the general is there, where he judges what to do with it, and he has to talk about the availability of it. We have Mr. Blue here from the Bureau of Mines, who probably knows more about the status of these experiments, as far as the Bureau is concerned, than anyone else. They have worked hard and been very helpful, and there are other companies working on it that we know about. We probably will have them before the committee.

There are companies which want to go in and use their own money, not using Government money, like the $15 million Titanium Corp. is using in Henderson, and the $15 million the Du Pont Co. is using in New Jersey. Well, they probably wouldn't tell us too much about the process, but if they turned out the metal, it wouldn't matter. We are highly encouraged that the price will come down, but we do know that you have to get production before the price can come down.

Who is going to stand that first price and how far shall you go? Maybe the Senators from Montana and Nevada and three other members of the subcommittee might have something to do with that. We hope we can, if we believe ourselves that it should be done.

Mr. GROSS. I am sure that you could count on a much more general use of this metal by the aircraft makers if you can accomplish those results, I am sure.

Senator MALONE. You are getting the raw material from Australia, which seems silly to a man from Nevada, when there is plenty of it all over the West, and I guess in the East too, all over the United States and Canada. There is a little difference in availability and use of ilmenite instead of rutile.

But when the war starts there are a good many people of our acquaintance who do not think you are going to get many ships across the ocean next time.

Mr. GROSS. Of course, it isn't all simple, even though the material were available and the cost were unimportant. We still have a lot of work to do in perfecting our processing and handling of it, because it has processing qualities that in every area are not of the best. It doesn't lend itself, as I understand it, well to making castings, for example. Castings are impossible. And it has this very unpleasant pickup characteristic, rubbing, where two pieces of the same material can't be used rubbing against one another. It tends to pick up, as the expression is.

Those things all take research on our part and on the manufacturers' part, even though the stuff is here. So I would like to throw one note of caution in: That these metals and materials, quite apart from their cost, there are other characteristics that have to be taken into consideration. Stainless steel has certain problems in working, processing; monel metal has.

Senator MALONE. All these metals when they first came along, aluminum, magnesium; weren't they all problems?

MUST BE DONE

Mr. GROSS. Yes. Well, all I say is that you shouldn't overlook the fact that there is more to it than just the availability and the price. We have still got to do a lot of work ourselves to perfect its processing.

Maybe you want to say something.

Mr. PAPEN. Senator, is your committee interested up to the point of producing sponge and pig, or are you going beyond?

Senator MALONE. We have 77 strategic and critical minerals, materials, and fuels. We would like to study each one as far as practicable, weighing the importance of each material.

With respect to titanium, we think the logs seem to be jammed—I think I am speaking for the committee—as to the volume of production of usable metal, and you have a terrific problem in your scrap, which makes it more expensive. Each one of these problems, it seems to us—maybe we are optimistic—you can whip better if you are in volume production than you can if you just have each company producing a small amount some place, and each company working independently and trying to use specifications that often are not uniform.

Mr. GROSS. Of course, I would like also to add that it has, quite irrespective of cost, safety characteristics that make it very dear to our hearts. We have aspirations in the commercial field, and we have been thinking about an advanced airliner, and I have a feeling that a good husky portion of the back end of that might be used; we might have a very general use of titanium.

Senator MALONE. On a balance proposition?

Mr. GROSS. Yes; and a safety. The hot parts and the warm parts can very easily find titanium as an answer to its problems from the safety standpoint. Of course, particularly in the commercial field, that is the first thing. And of course it does have very, very real and appealing qualities as far as payload saving in the commercial field too.

In the military it is translated into a little different factor, because we are thinking about the lives of our boys and not how much money an airliner can make. But the point is that, in both areas, the military and the commercial, it has very fine qualities and challenging ones, and we are interested. We have been right from the start, and we want to push it. But we need all the help you can give us.

Senator MALONE. Well, we need your advice.

Senator Murray?

Senator MURRAY. When you talk about the safety, you mean the safety of the plane from accident occurring?

Mr. GROSS. No. It is, again, on this piece of paper right here. It has to do with the heat-resisting qualities of this metal. From 250° up to 800°, it has much better strength properties and heat-resisting properties than its competitors.

Maybe you want to make a speech on that, George?

Mr. PAPEN. I talk in terms of weight rather than safety. We can get the safety by using heavier materials. Then we don't have a salable article: the first one will saturate the market. Titanium fills the bill of giving us the strength we need at the temperature we are operating, at an economic weight.

Senator MALONE. You have not only additional payload but less fuel cost under ordinary conditions?

Mr. PAPEN. Yes. You can translate it either way. You can take a given airplane and lighten the structure and carry more payload or you can start from scratch and design a lighter airplane, a small airplane, to carry the same payload. Depends on which approach you want to make. You have got a more efficient product either way you put it.

Senator MALONE. When you get to fighters and bombers, it just means they can go farther, carry more fuel, and do a better job.

Mr. GROSS. Yes, by making a smaller airplane do the same job or a bigger airplane do more job.

Senator MURRAY. Well, that is very interesting testimony. I am satisfied with what he has put in the record here. I think it will be very helpful to us in analyzing the problem when we get the hearings finished.

Senator MALONE. They know their business.

Senator MURRAY. Yes, they certainly do.

Senator MALONE. Go right ahead.

Senator MURRAY. This is very new to me. I had no idea about the complications that are involved. I have been hearing about titanium up in Montana. I think we get a little titanium up there, and there is a possibility for developing titanium in my State.

Mr. GROSS. One of the nice things about it, I understand it is one of the most plentiful minerals we have. It seems a pity, if that is the case, that we don't do something about it.

Senator MURRAY. It seems strange when it is so plentiful that it is so expensive.

Mr. GROSS. We have here material that I would think should go in your record. I would like to give it to General Metzger because it may have some classified.

Senator MALONE. The general has inspected it. Anything that is

not classified will be accepted for the record, and it will appear in the record as a part of Mr. Gross' testimony.

(The material referred to follows:)

REPORT ON TITANIUM, OCTOBER 15, 1953

In response to inquiry relative to use of titanium in our aircraft, there is no question but what reduction in the cost of titanium would increase its usage. At the present time our use of titanium is limited by two factors:

(*a*) Its cost relative to other materials.

(*b*) Lack of availability of the material in usable shapes, mechanical and physical properties, and quality.

Titanium is in demand in aircraft construction because of its corrosion and heat resistance, nonmagnetic properties, and favorable strength-weight ratio. Titanium is limited as much by lack of availability as by high cost. It has been estimated that the national titanium sponge production for 1953 will be approximately 3,300 tons; this is expected to increase to 22,000 tons by 1956. The conversion of titanium sponge to wrought titanium base metal will yield approximately 4 million pounds of usable titanium products in 1953, and 26 million pounds in 1956. A recent aircraft industry survey, ARTC–Elt–53–29, June 3, 1953, file W–67, stated that aircraft requirements were estimated to be 5 million pounds for immediate consumption, and 33,500,000 by 1956. In other words, at the time we have reached maximum presently planned production of titanium products, we will be from 2,500,000 to 7,500,000 pounds short of expected requirements.

Lockheed Aircraft Corp. is introducing titanium into its designs about as fast as production know-how and technique, material availability, and present costs make it possible.

A. Present production usage under present conditions:

Model	Weight/airplane	Weight purchased/airplane [1]
Cargo	559.0	1,398.0
Patrol bomber	22.6	50.0
Current fighter	39.33	80.0

[1] To take care of normal scrap plus abnormal scrap due to poor quality materials uncertain delivery, and learning.

B. Proposed usage:

In addition to the above, we have made many other investigations and are now considering the following in expectation of slight improvement in delivery schedule and quality of product.

Model	Weight/airplane	Probable weight purchase/airplane [1]
Advanced fighter	50.0	75
Patrol bomber	272.0	408
Constellation	420.0	630
Current fighter	200.0	435

[1] Lower than present usage due to expected improvement in utilization.

C. Costs:

Following are some explanations of the effect of titanium costs on our product:

I. JET POD DOORS

Unit cost per jet pod door

	Currently using 302 stainless steel	Proposed using RC–55 titanium at $20 per pound	Proposed using RC–55 titanium at $15 per pound	Proposed using RC–55 titanium at $10 per pound
Raw material	$314.45	$1,400.00	$1,050.00	$700.00
Labor, tooling	105.82	176.98	176.98	176.98
Total cost per door	420.27	1,576.98	1,226.98	876.98

1. Titanium usage reduces weight 44 pounds per aircraft.

Titanium cost at $20 per pound. The weight saved is valued at $26.30 per pound. (Questionable whether we should use.)

Titanium cost at $15 per pound. The weight saved is valued at $18.20 per pound. (Reasonable.)

Titanium cost at $10 per pound. The weight saved is valued at $10.40 per pound. (Would have been used without question.)

II. EMPENNAGE FITTING

	Steel	Titanium
Weight of forging, pounds	23.5	13.80
Cost of forging	$7.90	$325.00
Cost of machining	$58.00	$174.00

Weight saved by use of titanium in lieu of steel, pounds 5.9
Cost per pound of weight saved $83
(Completely unrealistic and not acceptable.)

III. TUBING

Material	Cost per foot	Cost per airplane
Stainless steel	$3	$18
Titanium	21	130

At these prices the cost per pound of weight saved was $35.

At $10 per foot for the titanium the weight saved would cost only $12 per pound. (A very acceptable condition.)

D. Types of parts now considered for titanium:

(*a*) In place of stainless steel in structural applications operating under 600° F.

(*b*) In place of stainless steel in applications operating over 300° F. and under 600° F.

(*c*) Shrouds, firewalls, baffles, corrosive areas, oil tanks, water tanks, bulkheads, fillers.

E. Types of parts we except to use titanium on in the future:

(*a*) Armor plate.
(*b*) Skins on high-speed aircraft.
(*c*) Flak plate.
(*d*) Tubing.
(*e*) As higher strength weight ratios are attained, titanium will replace stainless and other steels in structural applications.

F. General:

Naturally, the maximum benefits can only be obtained from titanium, as from any other material, when it can be applied during original design stages rather than as a substitute or replacement; and, of course, this route takes longer to get maximum utilization. The attached chart contains some additional statistics which may be of assistance. It is based on the natural assumption that the first line of attack for applying titanium is as a substitute for stainless.

In closing, it is important to remember that in the aircraft industry weight is of vital concern. It directly affects performance and value of the product. It is, therefore, economical in our industry to talk in terms of saving or reducing weight at such-and-such a cost per pound. Even so, any reduction in the cost either in the sponge, metallic titanium delivered to our door, or in the processing within our plant, will make titanium more attractive and increase its use. The same thinking applies to availability of high-quality sheet and bar. Any effort that can be made by the producing agencies, the airframe industry, or the Government toward increasing the availability of high-grade titanium at reduced cost will increase the demand for same tremendously.

Titanium versus stainless on a gage for gage substitution [1]

Model	Stainless steel sheet stock		Proposed usage of titanium sheet stock						
	Total pounds used per aircraft	Total cost per aircraft	Total pounds per aircraft	Weight saved over stainless steel	Current cost of titanium $21.75 per pound average	If cost at $16.75 per pound	If cost at $11.75 per pound	Cost of titanium per pound to equal cost of stainless	If weight saved is valued at $10 per pound cost of titanium could be [2]
				Pounds per aircraft	*Per aircraft*	*Per aircraft*	*Per aircraft*	*Pound*	*Pound*
Trainer	389.7	$213.86	231.5	158	$5,035	$3,878	$2,720	$0.92	$7.75
Fighter	782.6	460.36	464.9	318	10,112	7,787	5,463	.99	7.83
Patrol-bomber	3,441.2	2,417.50	2,044.1	1,397	44,459	34,239	24,018	1.18	8.02
Constellation transport	4,232.9	2,664.75	2,514.4	1,718	54,688	42,116	29,544	1.06	7.89

[1] On assumption that 90 percent of stainless now used could be replaced by titanium from a structural-functional standpoint.

[2] Most aircraft companies believe weight reductions are worth approximately $10 per pound. Most, including Lockheed, will go to $15 or $20 per pound, which in turn will increase the values in this column proportionately.

NOTE.—Density: Stainless steel, 0.286 pound per cubic inch; titanium, 0.170 pound per cubic inch.

Senator MALONE. Do you have any further statement you would like to make generally?

Mr. GROSS. No; except I feel that it is interesting that in our company—I wouldn't care to talk about individuals or specific instances——

Senator MALONE. I think that is the way to do it.

Mr. GROSS. I find a great deal of interest in this metal, and interestingly enough, there are some young men in our company who are trying to get out on their own and promote companies to find and mine and process this material, and I think they are looking for some kind of help. It is pretty hard to get private capital because it is a pretty speculative affair, and it takes enormous amounts of capital. But I have been interested to see the broad interest and enthusiasm that exists among young men about this metal, and it makes me feel all the more heartened that we ought to, as older men, get down and do something about it.

Senator MALONE. I think that it will stimulate interest just like some years ago I remember we had a program of making gold out of

sea water. People were very much interested in that and were investing their money.

Mr. PAPEN. Trying to make water out of gold here now though.

Mr. GROSS. Would you like to say something, George?

Mr. Papen really knows what he is talking about. I wish he would say something.

COST OF SPONGE IMPORTANT

Mr. PAPEN. There was one question, I believe, that prompted the report we sent in to you a week or so ago relative to the cost picture. It has been kicked around at Dayton. The effect of cost of sponge. We have heard a statement to the effect that reducing the cost of sponge isn't going to affect the cost to us. A dollar or, say, a $2 drop in the cost of sponge will affect us to the tune of about $5 or $6 a pound, because of the build-up in cost between sponge and us. So that any slight decrease in the cost of sponge will have a big effect on our end of the cost picture; and that is excluding the additional cost added as it is processed, just the cost of this same pound of material as it traveled along the line and lost some of itself in realization. In processing from sponge to metal, we realize 60 percent; and 40 percent of this metal is lost in making parts. Thus, for every pound of finished metal part, 3 pounds or more of sponge must be produced.

Senator MURRAY. What is the technical definition of sponge?

Mr. PAPEN. Is the equivalent of what we always used to call pig iron. Somebody else could give you all the chemical names, but as far as I am concerned it is pig iron. Can't be used for anything. That is one thing that has always bothered us. People in magazine articles keep going into all the sponge that is produced. All the sponge that is produced isn't worth a nickel to the airframe industry. It isn't until it is processed into bar, sheet, plate, forgings that it means anything to us. We don't care how much sponge you stockpile. Until it is a piece of metal that we can form and machine or put in an airplane, it isn't a product. We have to keep culling out the sponge all the time and get down to how much metallic titanium in usable shape there is available. There is very little of it.

Senator MALONE. What percentage of the sheet material that is furnished you has to be rejected on account of the lack of conformity to specifications?

Mr. PAPEN. Well, gentlemen——

Senator MALONE. I am just talking in general terms.

Mr. PAPEN. A year ago, 85 percent of the sheet. Today it is down to around 40 percent. That is sheet that is delivered to us supposedly acceptable and ready to use. It is getting better every day. I mean, I don't think we have too much complaint at Lockheed on that score. The material we are buying for our production orders is coming in on time, and is getting better in quality. Our own realization from that is only about 50 percent at this time.

Senator MALONE. A lot of scrap too?

Mr. PAPEN. Yes, and technique on our part. Within a year it will get down to probably 25 percent. It should eventually get down to the same as any other metal, 3 or 4 or 5 percent, depending on the efficiency of a shop.

Mr. GROSS. That is where these techniques that we have to perfect come in, you see. At the present time we have got lots to learn about this.

Senator MURRAY. How do you detect the defects?

Mr. PAPEN. It used to be you didn't have to detect it. You had to stand back so it didn't hit you. You lay it on this table, and it looks like somebody laid a soggy wash-cloth down. It was obvious it wasn't flat. We spend a lot of money making a smooth airplane, so we are not going to hang a piece of titanium on it that is all wrinkled. That was an obvious defect. The other defect which was common a year or two ago was lamination. The sheet would apparently lapse folds, and it came to us like shim, stock which we could peel apart. Those were the obvious types of defects.

Now, the other thing was that the physical would vary, right in a sheet. You would get different physical properties depending on where you took a test piece out. Those things are all improving. Today I don't think it is too bad. I don't know what other companies are running into. Our picture is very much improved.

Senator MALONE. Then doesn't that come right along like the general conversation in these hearings, that the greater the volume and the greater the use, the quicker all these problems will be solved?

Mr. PAPEN. All the things which are a matter of technique are going to just naturally be improved by the use. The things which have got to be looked at deeper than that are things which are dependent on the process. I think it is getting right back to the sponge.

Senator MALONE. Have you studied the matter of new processes that might be under consideration that might speed up or cheapen production?

Mr. PAPEN. No. I hear about them, but I couldn't talk about them.

Senator MALONE. We are going a little further into that particular phase of the matter. We are not through with it yet.

What you are talking about today is something, if there were no war emergency or no threatened war or threatened emergency, it might be a 20, 30-year job, I suppose, and it would just be a matter of economics then. But since we have been fed on emergencies for 20 years of different kinds—and we haven't changed it very much the last year—we are still talking about emergencies, it looks like it is time for Jim and me and other Senators, to take a good, square look at this problem, and see where we stand and what is important and what is unimportant.

As long as we think that national defense is important, and as you testified and as everyone else I think would readily conclude, if our potential enemy has this material, the cost is unimportant to us at the moment. If that proves to be right, which I cannot say at this point whether it is or not, then there should be more pressure on the contracts and more attention paid to people who are in the laboratories all over the United States. We will hear all of them before we are through and then see what we can add up. We might ask you to come before the committee again, and we are inviting you now, if you do develop more information you think of interest to us, to send it to the chairman or to any member of the committee at the Senate Office Building.

So the position of the committee, as I see it—and I think I can speak for the committee—is to be helpful, and see what can be done with this material that you yourself, Mr. Gross, say is indispensable in certain types of work in planes.

NEED MORE INTEREST

Mr. GROSS. I would like to urge, if it is proper to do so, that your committee give increased and serious consideration to letting out more experimental and processing contracts; I don't say to us, but to firms that might be induced to come into this business. You have only 4 or 5 sources that are working on it.

Senator MURRAY. What kind of plants would be liable to be interested?

Mr. GROSS. I should think the electrometallurgical plants and the big metallurgical companies.

Senator MALONE. We are looking into that end of it; for example, we are investigating. Mr. Alderman, our counsel, has already interviewed one company which thinks it has a new process. It is ready to put up several million dollars; not ask the Government for any money at all. You can't tell where a little encouragement here and there might lead to.

Mr. GROSS. The Air Force has given out, and with, I think, extremely good results in the last few years, contracts for processing studies—not making airplanes nor designing airplanes, but shop processing—and I would think there would be an enormous area for—perhaps the Air Force should do it—to put out contracts to engineering and technical organizations for study contracts in the field of cheaper production in this area.

Senator MALONE. That is one reason I requested General Metzger, who has all this at his fingertips, as far as what the Air Force needs or is about to do, to be here. He has testified at length before the committee. Before this hearing is over, we will ask him to make another brief statement. We have him with us for advice, and if he sees fit to recommend certain specific things, I think they will leave an impression on the committee. I think your suggestion is good.

I want to tell you, Mr. Gross, that we appreciate very much your appearance here.

Do you have anything further?

Senator MURRAY. No, I agree with the chairman. I think it has been very helpful to us.

Senator MALONE. I know your time is valuable, and we are very glad to have had you with us.

Mr. Atwood of North American Aviation Corp.

STATEMENT OF J. LEE ATWOOD, PRESIDENT, AND L. P. SPALDING, ENGINEER, NORTH AMERICAN AVIATION CORP.

Senator MALONE. Mr. Atwood, if you have anyone whom you want to bring along with you to the table——

Mr. ATWOOD. I have Mr. Spalding here of North American engineering laboratory.

Senator MALONE. Will you identify yourself for the record?

Mr. ATWOOD. J. L. Atwood, president of North American.

Senator MALONE. Mr. Atwood, you know generally the objectives of the committee. You have heard other testimony here, and without further ado I will just ask you the same general question. We are out here 3,000 miles from Washington, where influence ought to be at a minimum [laughter]—and I will ask you what is your actual use of titanium, and what you think it would be if titanium was workable and plentiful just like stainless steel or aluminum or any other material. You know what is important to you.

Mr. ATWOOD. Senator Malone and Senator Murray, I find it difficult to add much to the comprehensive statement of Mr. Gross and Mr. Papen, who, I thought, covered the subject.

Senator MALONE. We would like you to cover it from your own statement. It is corroborative and helpful.

Mr. ATWOOD. We too are very optimistic about the future of titanium in aircraft structures. We look forward with a great deal of confidence to the incorporation of considerable quantities of material.

First I would like to say that I am not prepared to testify with respect to the supply of titanium or with respect to industry figures, overall usage. But I believe I can give you some information with respect to our own company, the usage we have made of the material, and respective quantities that we expect to use.

Senator MALONE. You see, Mr. Atwood, all of the knowledge is in Washington, but when they really want to get anything done, they come down to someone who knows how to pay the help while he is doing it. [Laughter.]

Mr. ATWOOD. Well, Senator, our company makes the fighter planes, F–86's and the F–100's. I am not permitted to disclose the actual weights of these particular aircraft, but I would like to point out the fact that we are using titanium in all those planes. In our F–86's the plane has been in production for some years. We have incorporated approximately 1 percent of the weight of the aircraft: it has titanium structure. That is exclusive of engine or any equipment that would be supplied separately.

Senator MALONE. You are talking about the frame?

Mr. ATWOOD. Yes. That 1 percent is used in the locations where the maximum gain can be effected. In the F–86H, which is a major redesign of the same basic airplane, we are using approximately 2 percent of titanium, and gaining something in the overall weight of the plane.

The F–100 which we are just bringing into production incorporates 5 percent of titanium in the finished airplane weight.

Senator MALONE. What is the name of the plane?

Mr. ATWOOD. F–100. It is a new fighter plane we are bringing into production for the United States Air Force.

Now, here is a technical point I would like to bring out here that neither Mr. Gross or Mr. Papen made, insofar as I heard their remarks:

In designing an airplane we find that the overall weight is proportional to certain basic original weights; in other words, the starting point, such as the disposable load Mr. Gross mentioned or armament weight that is carried in the military plane, or the structure that the plane carries around as part of its own weight.

Now, when we develop a very high-performance fighter plane or something like a guided missile, wherein performance that is, speed, altitude, are the prime design parameters, we will find that, saving as much as a pound in the weight we use as the initial load, we can save 3, 4, 5, or 6 pounds, sometimes as much as 10 pounds, in the final weight of the airplane. That is because, for each pound of starting weight, we have to provide certain wing area, certain tail plane area, certain amount of fuel, to carry the weight, certain amount of engine power to propel it, and certain size fuselage. Each pound, theoretically, starting weight adds a certain increment to the overall plane.

In the case of a high-performance military plane, saving 1 pound in structure or in fuel or in armament, no matter where we save it, at the design stage, we can save 3, 5, possibly 7 pounds in the final weight of the airplane. That is where the economy of titanium pays off in a military design. It isn't that we save 1 pound by substituting 3 pounds of titanium for 4 pounds of steel; we save more. We save quite a lot in the size of the plane we are designing if we do it at the design stage. If we wait until we are all through and then replace stainless steel with titanium, we only save pound for pound.

Senator MALONE. In other words, if you put in 1 percent of the weight of an F–86, it makes a lot of difference in the final completed weight of the F–86?

Mr. ATWOOD. Yes. The final weight of the plane can be 3 percent less, as a result of saving that 1 percent. I make that one point in passing.

This year is the first year of large usage of titanium in our company. I don't know exactly what our usage is going to be this year, but I estimate it is going to be 250,000 to 300,000 pounds of sheet titanium, titanium alloy.

Next year our contracts and our designs that go with them call for the usage of about 830,000 pounds of sheet titanium, pure and alloy. In each instance the ratio is about 75 percent alloy sheet and 25 percent pure titanium sheet.

The following year, 1955, our requirements at present are for 790,000 pounds of titanium, somewhat less; that is the firm scheduled usage that we have. It may increase as time goes on.

Senator MALONE. That accounts for the contracts you now have?

Mr. ATWOOD. Yes.

Senator MALONE. In other words, the point was made this morning—we are now talking about preparation and keeping up the pace we have now established—if all at once some real emergency threatened, and we suddenly speeded it up like they did during World War II, then you would really be in business?

BIG FIELD FOR TITANIUM

Mr. ATWOOD. Yes, sir. Now, with respect to the maximum possible usage of titanium, I think it is rather speculative to quote any percentages, but I would say that, from the 5 percent we have incorporated in the F–100 to the possible 60 or 75 percent that might go into some types of design that we are contemplating at this time—only in the contemplating stage—we have a big field there for possible application of this material.

When I say we are contemplating possible usages up to 60 or 75 percent, I only indicate that I referred to possible designs wherein the surface temperature would be in the 250° to 800° bracket that Mr. Papen mentioned. In that case it would be economical to make substantially the entire structure of titanium, in accordance with the curve he gave you here.

Senator MALONE. Then, in order to get into the record something on which the committee might base conclusions upon, suppose you were up to your 60 to 75 percent right now, in your present program, where would that put your use in 1953, 1954, and 1955? That would be quite an increase, would it not?

Mr. ATWOOD. Certainly.

Senator MALONE. Without any increase in the rate of construction. Just trying to get some idea of where we would be now if you had had 3 years ago the information you now have.

Mr. ATWOOD. Senator, I might state that these things can only be considered in the perspective of timing, and when I say we are contemplating designs, I refer to a period 10 to 15 years ahead when I speak of such high percentages.

Senator MALONE. That is what we thought about a lot of things that were speeded up. Would it be possible that under emergency conditions that production would be speeded up?

Mr. ATWOOD. It is very possible.

Senator MALONE. Providing they could perfect the processes fast enough and in time, and secure workable supplies that were necessary?

Mr. ATWOOD. Those things all go with it, and that really brings me to the next phase of the comment I wanted to give you.

We are experiencing many difficulties in the use of titanium because it is a new material. We are not properly prepared to make all the applications we would like. We can't weld it satisfactorily, for one thing. Welding has a very limited application for titanium. We have difficulty in forming it. Machining it is extremely difficult, as you have probably heard. So we are somewhat circumscribed in our application of this material.

We feel that the growth of the application—titanium aircraft—will involve technological improvement in the material itself, technological progress in our utilization, reduction in cost, because some of the applications are marginal. We weight it in respect to a practical decision. Finally, the improvement in supply.

Lastly, the utilization and design, which is an evolutionary thing at best; the rate of that evolution, as you say, is subject to variables, and I am not a very good prophet. Past predictions haven't worked out too well with respect to time, so I am getting more and more reluctant on these things as I go along.

Senator MALONE. Well, it will be just like any other material. Perhaps you would not have had synthetic rubber in 25 years if you hadn't had to have rubber on a "right now" basis.

Mr. ATWOOD. That is right.

Senator MALONE. That was the basis of my question: That when we have to do a thing, we generally do it. If we don't have to, why, we just go along and develop it gradually.

Senator, you have any questions?

Senator MURRAY. I would be willing to hear his predictions. I think he is in a better position to make a prediction than I would be.

Senator MALONE. I think we should hear the predictions, understanding thoroughly that they are just predictions.

Senator MURRAY. We won't hold you guilty if you don't hit the right mark.

Mr. ATWOOD. I will backtrack just one step then.

Senator MALONE. They said it might be an educated guess. But some people said that planes wouldn't fly at all. That hasn't been too long ago.

USE LIMITED AT THIS TIME

Mr. ATWOOD. The use of titanium now is limited, for practical considerations, to hot points in the airplane. The 5 percent we use in the F–100 is right adjacent to the engine, where there is a tremendous amount of heat. By using it, we can bring the structure a little closer to the hot engines, wasting a little less pumping effort in ventilating, and get a little more efficient airplane, and save some weight. We don't have a powerplant available to us that will enable us to make sustained flight in the order of 2½ times the speed of sound, and until we get to such speeds, the aluminum skin of the airplane is fairly satisfactory from a structural point of view. That is why I mentioned the period of 10 or 15 years for the possible total application of titanium.

Today we would not put titanium on the wing surfaces of an airplane such as the F–100 even if it were the same price as aluminum, be cause there would be no basic structural advantage. We will apply it to the wing surfaces and the fuselage surfaces when our speed gets to about 2½ times the speed of sound or higher. We don't have a powerplant to enable us to go that fast as yet, that is, sustained flight. We move along a step at a time, and while we will have missiles operating pretty fast, with short bursts of speed, I think we are going to have a lot of aircraft and men in them that fly, not only below 2½ times the speed of sound, but below the speed of sound itself, for a long, long time to come.

On those applications we will only use titanium in hot spots, that is, points artificially heated by engine or exhaust impingement temperature. It will be a gradual expansion as far as the general use of titanium is concerned. Five percent in the F–100 is a good economic application. We are getting our money's worth there many times over. We could use a little more, but it would begin to get marginal. It would be marginal if we went to 10 percent right now, quite marginal. So, while I am perhaps not painting a very clear picture, I see at one end of the scale, when we reach very high speed flight as a regular thing, that we will approach 60 to 75 percent titanium possibly, but for the immediate future, it is going to be just a progressive increment in the use of titanium.

Senator MALONE. What about a powerplant necessary to fly at, say, twice the speed of sound or 1½ times the speed of sound or in the area where the use of high-temperature-resistant metals becomes necessary?

Would you have any prediction as to how far such a powerplant is away?

Mr. ATWOOD. Well, sir, that is a difficult thing. Right now we have rocket-type powerplants that will give a burst of speed in that category. But the missiles don't heat up much in 30 seconds. Maybe it

would in 30 minutes or 20 minutes. We don't have a powerplant that will give us sustained speeds of that order.

Senator MALONE. For a plane?

Mr. ATWOOD. That is right. So I think that 10 or 15 years for broad application of that degree of supersonic flight is the best estimate I can give you.

Senator MALONE. There are people talking about uranium fuels for airplanes. Of course, that may be out of your field. It certainly is out of mine. But only a few years ago, they were not predicting uranium fuel for anything. Now, the Government is going to build, I believe, a hundred thousand kilowatt commercial powerplant, hoping it will be commercial, at least for that purpose. They have a submarine that is to be powered by atomic energy; some of the information is classified, but progress has been very satisfactory.

Of course, we are clear beyond what we are now doing, and it is a little out of our field. The prediction is hazardous, as you say.

Someone has just called my attention to the fact that the jet engines 10 years ago had about a 6-minute range. Now, of course, with the improvements and the fuel and all, I do not know what the range is, but it is quite considerable.

Mr. ATWOOD. We have substantially doubled our speed.

Senator MALONE. That was done in 10 years?

Mr. ATWOOD. Yes. We have doubled our speeds in 10 years, yes, sir.

Senator MALONE. Do you have any questions?

Senator MURRAY. No.

Senator MALONE. All right.

Senator MURRAY. Would that material be helpful to us if we had it on the record, that you have?

Mr. ATWOOD. Sir, you are certainly entitled to it. Some of it has been marked up, naturally.

Senator MALONE. This material will be accepted and appear in the record as a part of Mr. Atwood's testimony, subject to General Metzger's examination.

(The information referred to follows:)

Commercially pure titanium is a little stronger than 75S–T aluminum or annealed 18–8 stainless steel. It is 65 percent heavier than aluminum and 40 percent lighter than steel.

The titanium alloy sheet now in use at North American Aviation (7 percent manganese) is about 70 percent stronger than 75S–T and a little weaker than one-half hard stainless, with weight comparisons as above.

On a strength-weight ratio basis, it can be broadly stated that titanium alloys rank above other common structural materials in the temperature range of 300° to 700° F. Below 300° aluminum is superior; above 700° stainless steel is preferred. This explains our present use of titanium in the heated structure around jet engines. Commercially pure titanium is a useful replacement for stainless steel in firewalls and shrouds, where fire resistance rather than strength is sought. Actual parts in use show a weight saving of 10 to 40 percent.

Future potential usage of titanium is contingent on several items. (1) Stronger alloys (whose development is a certainty) will compete favorably with aluminum or steel over a wider temperature range from 300° to 700° F., resulting in greater use. (2) If airplanes become fast enough (over Mach 2–2.5) to raise skin temperatures above 300°, aluminum would be replaced by titanium in many applications, including both airframes and missiles. (3) If the price drops, applications which are now marginal (e. g., a 5 to 10 percent weight saving) would become economically justifiable.

Our present sources of titanium are Rem-Cru Titanium, Inc., Republic Steel Corp., Mallory-Sharon Titanium Corp., and Titanium Metals Corporation of

America. Of these only Rem-Cru and Republic can supply alloy sheet at present.

Titanium sponge requirements may be estimated using the figures from one large producer who achieves a 60-percent recovery in producing sheet from sponge. He is currently remelting 10-percent scrap and expects to achieve a 25-percent usage sometime next year. These figures, combined with our previously cited sheet requirements, result in a 1,200,000-pound sponge requirement in 1954 and 1,050,000 pounds in 1955.

The titanium sponge supply picture is not too accurately known to us. We understand that production is scheduled to reach 20 tons per day in 1954, equally divided between du Pont and Titanium Metals Corp. The Crane Co. is scheduled to produce 15 tons per day beginning in 1956, giving a total of some 13,000 tons per year. These represent firm commitments; however, based on past performance, there is no assurance that all segments of the industry will meet these production goals. Additional capacity to provide a total of 25,000 tons per year has been discussed, but no contracts or facilities have been established for this expansion.

Deliveries of titanium against production orders have been unsatisfactory since our first usage, about 3 years ago. We have never been without shortages (mostly alloy sheet) and have resorted to substitutions of stainless steel (with weight penalties), diversions of material from other contracts, and delayed incorporation of titanium in some models. Technological problems of ingot production and sheet rolling were the major delaying factor up until recently. Now, and for an extended future period, it appears that the shortage of titanium sponge is the controlling factor.

Manufacturing difficulties have been encountered with titanium, chiefly in the fabrication of sheet metal parts. This was expected, and our experiences have been about the same as with the introduction of any new material into production, with one exception. The titanium sheet (especially alloy sheet) as received from the mills has been notably inconsistent in physical properties, and even gage thickness, from lot to lot and from sheet to sheet within a lot. Substantial variations have even been found in a single sheet. This situation has improved, and our rejection rate has steadily decreased, but further improvements are urgently needed.

Research and development has progressed rapidly in all phases of titanium technology. Work on basic metallurgy, leading to improved alloys and their better utilization, is considered adequate with respect to breadth of coverage and rate of progress. The technology of melting, rolling, and forging is under intensive study by the several producers. While improvements have been made, vigorous and continuous effort is required to achieve a more uniform product. We understand that several new methods of ore reduction are being studied, with the hope of achieving a more economical process. Whether production is ultimately expanded through these new processes or by improvements in existing methods, the need for more efficient titanium metal production is pressing. As a sidelight, we are advised that a substantial portion of our present titanium supply is derived from rutile ores, most of which are imported. Reduction processes which would utilize the domestic ilmenite ores deserve consideration from the strategic and logistics viewpoint.

Senator MALONE. I intended to ask you, when we got on another tack, if the deliveries of the titanium that you have been promised and that you are counting on, are satisfactory, and if the quality generally is satisfactory? How about the time of delivery; is that satisfactory?

Mr. ATWOOD. We have had considerable delay with respect to that. We have made some substitutions. Possibly I could ask Mr. Spalding to describe some of that in a little bit more detail.

Mr. SPALDING. Well, over approximately a 3-year period that we have been using titanium, we haven't ever, I believe, been without some shortages or delivery delays, and we have resorted to substitutions of other material, diversions of the available titanium from one contract to another, favoring the more critical applications, and delaying the incorporation of titanium in certain models for which it had originally been planned.

Mr. ATWOOD. Substituted steel in many cases?

Mr. SPALDING. Yes; stainless steel.

Senator MALONE. At the expense of more weight?

Mr. SPALDING. Yes.

Senator MALONE. It is like any new metal. You are just using it as fast as you can get it and speeding up in accordance with the supply.

Mr. ATWOOD. Yes.

Senator MALONE. Do you have any other information that you think would be helpful to the committee? Some of it may seem rather simple to you, but you understand the committee will have to start from scratch in the understanding of this business.

Mr. SPALDING. There is one point that possibly hasn't been brought out as yet. These figures of 1, 2, and 5 percent of the airframe weight being used on different models, those represent the actual parts on the airplane. In considering the amount of titanium that we need or that needs to be produced, of course, we must buy a larger figure to make up for scrap and other unavoidable losses. The figures are roughly doubled, a little higher. It turns out that our net yield is in the neighborhood of 40 percent of what we buy.

Senator MALONE. Rejects?

Mr. SPALDING. Well——

Senator MALONE. The usable material?

Mr. SPALDING. Usable material.

Senator MALONE. That includes the scrap loss and the rejects?

Mr. SPALDING. Yes. When we speak of scrap, we think of manufacturing errors, broken parts, and things of that kind. In addition to that, there are the unavoidable trimming losses.

Senator MALONE. I meant to include that.

Mr. SPALDING. Yes.

Mr. ATWOOD. In that respect, you might point out that we are using this in heavily formed parts, so there is a lot of trimming and shaping to be done.

Senator MALONE. As I understand it, then, you said that about 40 percent is actually usable and consumed in the manufacture; the rest is either rejection or scrap or——

Mr. SPALDING. Other loss, unavoidable loss; yes.

Senator MALONE. Well as titanium becomes more plentiful and more in general use; wouldn't there be a tendency to reduce that loss?

Mr. SPALDING. Yes; I am sure the loss will go down. As a matter of fact, in one category, that of what we normally consider rejects, in other words, broken and defective parts, it has been cut almost in half over the last 6 months.

Senator MALONE. Shouldn't that come down something comparable to other metal eventually?

Mr. SPALDING. Yes; I expect that it will.

Senator MALONE. What would that be?

Mr. SPALDING. Well, I think that a net yield of perhaps 50 percent is a good figure.

Senator MALONE. Including scrap loss?

Mr. SPALDING. Fifty percent scrap loss, fifty percent parts on the airplane.

Senator MALONE. Fifty percent loss, you mean, would include the rejects and the scrap loss?

Mr. SPALDING. Yes.

Senator MALONE. You think that is about as good as you would do over a period?

Mr. SPALDING. I believe so. It depends on the type of parts that are being made a great deal. I think our experience with stainless steel indicates about the same 50-percent figure, and that, of course, is a well-established material.

Senator MALONE. That 50 percent, how much of that 50-percent loss would be scrap?

Mr. SPALDING. Just bad parts due to faulty manufacture?

Senator MALONE. No; scrap, that would be good material, but it is simply trimmed off, due to your manufacturing shapes and trimmings.

Mr. SPALDING. All of it, if I understand you correctly.

Senator MALONE. Let me make it a little plainer. There are still considerable rejects because the quality is not right; that runs pretty high now?

Mr. SPALDING. Oh, I'm sorry. I see your point.

Senator MALONE. We hope that solving of the quality problem will mean fewer rejects. What part of the good material you put into your machines, results in scrap?

Mr. ATWOOD. Senator Malone, if I may say a word there——

Senator MALONE. My question is a little awkward.

Mr. ATWOOD. Our use of all materials, that is, sheet materials, involves a lot of cutting out, cutting to shape, size. I don't think we could expect, on a fuselage of a plane, to use over 50 percent of the aluminum we——

Senator MALONE. It is all good; it is just a question of trimming?

Mr. ATWOOD. Trimming, shaping, forming.

Senator MALONE. That makes the reclaiming of the scrap very important?

Mr. ATWOOD. Yes, sir.

Senator MALONE. If you could whip the scrap problem by reclaiming it at reasonable cost like you could steel, you could greatly lessen the cost of your product quite materially, wouldn't you?

Mr. ATWOOD. If that reflects in cheaper titanium mill price——

Senator MALONE. Shouldn't it?

Mr. ATWOOD. I should think it would.

Senator MALONE. If you could work it like you can steel?

Mr. ATWOOD. I should think so.

Senator MALONE. I don't know how imminent that is, but at least that seems to be a problem that, if you could whip it, would mean a lot of progress.

Mr. ATWOOD. We have no information on that, but I know it is a very difficult situation.

Senator MURRAY. When you have rejects, and it is because of defective material, who suffers that loss, your plant or the place you get it?

Mr. ATWOOD. Defective material we can send back. We haven't rejected too much of the material; we have cut it. We have cut it into pieces and we have utilized it on proper application; that is, if it is perhaps variable in thickness, we can utilize a piece that is thinner than specification in another application, which we do. We try to keep from sending it back; it is so hard to get.

Senator MALONE. You have any further questions?

Senator MURRAY. No.

Senator MALONE. Do you have anything further?

Mr. ATWOOD. I don't believe so.

Senator MALONE. Mr. Atwood, we certainly appreciate your appearance here, speaking for the committee, and if you should have any further thoughts along this line, or any material you think would be helpful to the committee, I hope you will not hesitate to send it in to us, Senate Office Building, in Washington. Thank you very much.

Mr. Raynes, of the Rohr Aircraft Co.

You have Mr. McCrary with you?

STATEMENTS OF BURT RAYNES, VICE PRESIDENT, MANUFACTURING, AND F. E. McCREARY, VICE PRESIDENT, ENGINEERING, ROHR AIRCRAFT CO.

Senator MALONE. Mr. Raynes, will you identify yourself for the record?

Mr. RAYNES. Burt Raynes, vice president, manufacturing, and F. E. McCreary, vice president, engineering.

Senator MALONE. Mr. Raynes, you have heard the testimony. You know the objectives of the committee. Would you just in your own way give us your experience in the use of this material?

Mr. RAYNES. Well, there is a great deal of value that has been given by Mr. Gross and Mr. Atwood. We generally subscribe to the things that were said by them.

Our situation is somewhat different in that we are a subcontractor, whereas they are prime contractors. We, perhaps, with the exception of North American, have used more titanium than anyone else in the airframe industry. Perhaps that is why we were asked here.

The quantity which we have used and which we have proposed to use in future years, we have here; however, that will be included, I am sure, by the prime contractors, Douglas, Boeing, and Lockheed and the others, for whom we make parts of titanium, will show in the weights that are required. They will show the figures that we would show, and it would only confuse and double up on the numbers if we submitted requirements at this time.

One of the things which we might add, in addition to the two discussions that were just recently held, is the matter of segregation between commercially pure material and the alloy material. I believe that some of the things, in the light of our experience, some of the things that have been said could apply only to one or the other of those two materials. The commercially pure material, in our experience, is fairly readily available. We have been able, in the past 2 years, to obtain the material that we needed through our various suppliers.

Senator MALONE. Who are your suppliers?

Mr. RAYNES. Well, we have bought from all of the suppliers; Remcru and Titanium Corp. and Mallory-Sharon and Republic have been our suppliers.

Senator MALONE. They are the three main suppliers?

Mr. RAYNES. Yes. We currently have on order, I believe, about 90,000 pounds of material, and it is spread between the various people.

All of this material that we have on order, with the exception of some experimental material, is commercially pure.

The two materials, commercially pure and the alloys, are completely different, and any consideration of the materials must be categorized into those differences, because the problems of manufacture to the fellow who has the mill are very different. The problems of manufacture in the airframe industry are very different, and the potential utilization of these materials is very different between commercially pure, which is a relatively low-strength material, and the alloy material, which is high-strength material.

Senator MALONE. Will you give us, for the benefit of the record, a description of just what you mean?

Mr. RAYNES. The commercially pure material is, as the name implies, material which contains only trace amounts of less than 1 percent of other elements, such as nitrogen, oxygen, iron; and the alloyed materials are materials which are specifically alloyed with other elements to increase the strength. The commercially pure materials run, according to the new specification, from 80,000 pounds per square inch, and there is no top limit. However, the top limit is about 140,000 pounds per square inch, whereas the alloyed materials developed strengths of—basic strengths of 150 to 175,000 pounds per square inch; tensile values, general.

I think Mr. Atwood suggested that they used 75 percent alloy material, 25 percent commercially pure. I think, to be sure that the record is clear, that represents one of his procurement problems, in that alloy is real tough to get. It definitely is just on the fringe of our total knowledge in getting it.

The utilization which he showed of 40 percent net, I believe—and I am not speaking for him—but from our own experience, his utilization is that low because he is utilizing such a high percentage of alloyed material. Mr. Papen can perhaps speak for Lockheed in that respect. I see he is still here. The alloyed material is much more difficult to use.

Senator MALONE. What is your percentage?

Mr. RAYNES. We get about 40 percent scrap. We have about 60 percent utilization from the mills at the present time into the flying article. From the poundage we get from the mills to the flyaway article, we utilize about 60 percent at present. That is commercially pure.

Senator MALONE. Forty percent lost then, both in scrap and in impure material in——

Mr. RAYNES. No; that is of what material we will accept on our receiving dock.

Senator MALONE. In other words, then, it is only the scrap loss and other natural loss in the manufacture?

Mr. RAYNES. Not losses due to our receiving loss or what we count unacceptable material.

Senator MALONE. What do your rejects run, generally speaking?

QUALITY IMPROVED

Mr. RAYNES. I reported in General Metzger's meeting last March that our losses through 1952 were slightly over 32 percent. That is what we rejected on our receiving dock, and our loss now is down

around 10 percent or less. The quality we feel is much superior to what it was in 1952.

Senator MALONE. This is the commercially pure?

Mr. RAYNES. Commercially pure material is all I am speaking for.

Senator MALONE. Now, when you get over into the category of the alloy, titanium alloys, how does that shape up?

Mr. RAYNES. I can't speak too much from our own experience, but from hearsay it is a tough go.

Senator MALONE. Most of your use then is——

Mr. RAYNES. All of our use, other than experimental purposes, is commercially pure material.

Senator MALONE. Why is that? Does the type of parts that you are manufacturing just happen to be in that category, is that it?

Mr. RAYNES. That is right. There is a limited application, we feel, in our product, which is powerplant assemblies, for commercially pure material. There is a wider application for the alloyed material, assuming you get all the problems licked, the mills and in the actual fabrication techniques.

While we are on that subject, we feel that the problems connected with commercially pure fabrication are fairly well resolved; connected with commercially pure material, we can weld it, both by fusion welding and spot welding; our processing is satisfactory; our forming is not exactly satisfactory but we are doing it. Where we are getting parts, if you don't discount cost——

Senator MURRAY. You are talking about the pure?

Mr. RAYNES. Commercially pure.

Senator MURRAY. The alloyed doesn't weld well, is that right?

Mr. RAYNES. That is very difficult to weld.

Senator MURRAY. Bending the same way?

Mr. RAYNES. It is very difficult to bend. I don't want to imply that the commercially pure material is easy to form; there is a lot of people that know differently. We have gone to a great deal of research, spent 2 years.

Senator MURRAY. You are just saying you whipped it as far as you are concerned?

Mr. RAYNES. We think we have got it fairly well whipped.

Senator MURRAY. I was thinking it would be a good thing for me to go into that business if it was so easy.

Mr. RAYNES. It must be formed hot, and as the tensile ranges go up, as they have, by virtue of the removal of the top limitation on the Federal mill spec., we find the tensile values are creeping up. Our average tensile values as received on our receiving dock are higher. You need more and more hot forming, which is expensive.

Senator MALONE. Do you have any questions?

Senator MURRAY. No.

Senator MALONE. Did I understand someone to say, or is this some other conversation where it was indicated to me that in cutting the titanium, it was heated to a very high degree; it was necessary to heat it to cut it properly?

Mr. RAYNES. Not for sheet metal. Perhaps——

Senator MALONE. Alloys?

Mr. RAYNES. No; not for commercially pure or alloy either for sheet metal. There might be some machining technique wherein it was heated, but I know of no such application.

Senator MALONE. It is not necessary to heat it to cut it in either case?

Mr. RAYNES. No; but the forming—we have to bring ourselves to the point of view that we are not going to form these metals, either titanium or a lot of others, in an atmosphere or a climate that is suitable to our own particular likes or dislikes. We have to suit the forming environment to the metal itself.

Senator MALONE. Is that when it is necessary to heat it?

Mr. RAYNES. So we heat it.

Senator MALONE. How high a heat? What is the range in this forming?

Mr. RAYNES. 900° is the top that we use.

Senator MALONE. And down to——

Mr. RAYNES. Down to 550.

Senator MALONE. 550° to 900° is the range of the pressing into shape or forming the shapes?

Mr. RAYNES. Yes.

Senator MALONE. Go right ahead if you have anything else.

Mr. RAYNES. I mentioned the quality. The quality has improved greatly, although the quality standards of comercially pure titanium would be highly unacceptable in a normal commercial material such as stainless steel. We would not accept stainless steel under the quality conditions that we take titanium.

Senator MALONE. You wouldn't accept this if you knew it was available in a more usable form, workable order?

Mr. RAYNES. A portion of our increase in utilization off our receiving dock during the last year has been a slightly more liberal viewpoint on our own, although we always were liberal. You have to be with new materials.

Senator MURRAY. The defects are not always observable on inspection; isn't that true?

Mr. RAYNES. Not all, but fairly well so, fairly well so.

RESEARCH ON SCRAP RECLAIMING

Senator MURRAY. Latent defects instead of patent.

Mr. RAYNES. The reclaiming of scrap we would like to emphasize. We think that is of interest to the taxpayers and everyone else, that that be an area for research that would be very fruitful.

Mr. McCreary may have something he wishes to add on the potential use of the material as a structural material.

Most of what we have used in our present contracts, while we are using it essentially as a replacement for stainless steel, it was done in the initial design, as Mr. Atwood brought out, so it lowered the weight of the total airplane.

Mr. MCCREARY. I think we have covered that fairly well. I would like to add though that in order to realize full utilization of titanium in structures, I think it has been brought out very strongly so far that we have to develop the alloy of titanium. The commercially pure is pretty well behind us, ar far as our basic thinking. The alloy is well ahead of us. The development of the alloy itself and the development of the processes in the shops and the manufacturing processes, is where the work is going to have to be. That is where it is going to take some time to develop it, both in the manufacturing of the alloy and in the aircraft industry.

Senator MALONE. Are you familiar with the alloys in general, that is, the use of material to manufacture alloys?

Mr. MCCREARY. Right now we are using alloys basically in the form of forgings and in some sheet stock. The sheet stock is well on its way.

Senator MALONE. But what material do you use with titanium?

Mr. MCCREARY. Chromium, aluminum, manganese, small percentages of it to gain your strength. I think that is about all I could add on the structural application. In order to realize the 60-percent figure that you are going to use in the airplanes of the future that has been mentioned before, material must be in the form of alloyed material rather than commercially pure. Commercially pure has just about reached its limit with respect to items in the airplane for which pure titanium may be logically used.

Senator MALONE. You would still use some commercially pure, but when you increase the amount materially, you would go into alloys?

Mr. MCCREARY. You would have to. Commercially pure today is being used pretty well to its full extent, such as firewalls and shrouds around the hot engine parts. The alloys are the ones that are going to have to go on further and carry the utilization on to the point we have been talking about.

Senator MALONE. Where you need the high tensile——

Mr. MCCREARY. The strength-weight ratio isn't going to be in favor of titanium if you don't have the alloyed material. The strength-weight ratio will favor the aluminum alloys or the stainless steel.

Senator MALONE. The future is in the alloy?

Mr. MCCREARY. Yes.

Senator MURRAY. Are manganese and chromium used extensively?

Mr. MCCREARY. Aluminum, chromium, and so forth.

Senator MURRAY. Manganese has the effect of strengthening it too, doesn't it?

Mr. MCCREARY. I wouldn't want to get into the metallurgical part of it.

Senator MURRAY. We produce that in my State, and I want to sell it.

Mr. MCCREARY. I wouldn't want to comment.

Mr. RAYNES. We are very enthusiastic about the material. We have spent a lot of effort on it. The material has a great future, and we are spending a lot of our own funds and also Government funds on research in the fabrication techniques of this material. We have a research and development contract currently which we are working on on the hot forming of this material, titanium.

Senator MALONE. What do you mean "hot forming"?

Mr. RAYNES. The equipment and knowledge of how to form this material didn't exist 2 years ago, so something had to be done to create that, and a portion of the expense was carried by the Air Force through General Metzger's office. It is a research project. There are a lot of those.

Senator MALONE. Do you have any questions?

General METZGER. No.

Senator MALONE. In general, looking ahead, the principal reason this committee is now working on these 77 strategic and critical minerals, materials, and fuels under Resolution 143 of the Senate

because of the existence of an emergency. Now, if this emergency should tighten, it would be just as important to get additional titanium into these planes as it was to get synthetic rubber in World War II, when we couldn't get any kind of rubber.

I judge, from your testimony, that you believe practically all of these problems will be whipped just like they have been in other materials, but the time will depend on the pressure of the need; is that right?

Mr. RAYNES. That is substantially right, surely.

Senator MALONE. In other words, they are furnishing money to you for research because it is important to the Air Force, meaning to the Department of National Defense, to know how to use this material. Otherwise, $15 million to the Titanium Corp., $15 million to the Du-Pont Co. to provide initial equipment to manufacture titanium would not be provided in the first place.

So doesn't it depend on how bad the Department of National Defense wants this material and what money Congress is willing to put into it? I judge from your testimony that you believe these things could be whipped; it is a question of the timing, the money, and the pressure that is put on it?

NEED DEMONSTRATED

Mr. RAYNES. Well, there is a demonstrated need for titanium. I am not in a position to know how much private capital is being expended; I understand some is; toward developing the source for titanium, a supply of titanium. That undoubtedly is the best way to get the ball rolling. It will be the least expensive in the long run. But there is a demonstrated need for titanium; there is no doubt of that.

Senator MALONE. Perhaps my question wasn't too clear. We are groping, as you all are; you know one phase of it; someone else like Republic or the Bureau of Mines knows another phase of it. It is necessary for us to coordinate the information to make any recommendations.

My question to you, with your basic knowledge of utilization of the material, was: Do you see anything in this material that they haven't experienced in the last half a century on all new materials? Maybe there are a few tougher problems. But if it is necessary for you to make airplanes out of titanium, and Congress so decides and furnishes the money, do you see anything that couldn't be whipped within a reasonable time?

Mr. RAYNES. No. The problems are greater than with other materials, but there is a greater amount of talent to employ in the solving of these problems, and they will be, under the present methods that are employed, they will be solved.

Senator MALONE. Considering that 2 or 3 years ago it was almost an unknown material as far as volume use and production was concerned, and considering the progress that has been made in those 2 or 3 years, isn't it reasonable to suppose that if some other country, a potential enemy, is in this business, we could keep pace or outdistance anyone if we were furnished the wherewithal to do it?

Mr. RAYNES. The use of titanium and the techniques involved in its manufacture and its fabrication are an important part of our national defense program. It is a metal which, on the basis of its engi-

neering qualities—all metals compete with one another on the basis of engineering properties—this metal is becoming increasingly successful.

Senator MALONE. Would you put it this way: As far as the lightness and weight, relative to the strength and to the heat-resistant qualities, that it is in a class by itself at the moment for general building materials?

Mr. RAYNES. That is a difficulty. Nothing is in a class by itself, really. Mr. McCreary can answer that question.

Senator MALONE. Maybe I have asked the question awkwardly. What I am trying to get at, how important is it that we whip these problems if we really have a national defense emergency?

Mr. MCCREARY. I agree somewhat with his statement that I don't believe any metal can be put in a class by itself. All metals have a certain application for any engineering problem, and we have looked at titanium here and we can see that in the future, where we are getting skin temperatures on the order of 250 and over, titanium would well become the important metal, as far as aircraft structure.

Senator MALONE. In a class by itself there?

Mr. MCCREARY. Yes; with that application. But that is some years in the future. So it depends entirely upon the application you are going to put it to. Each metal has its own place. I don't say it will ever replace stainless steel in its entirety, or aluminum; each has its place.

Senator MALONE. But there are places, to be specific about my question now, where, due to its lightness and strength, relative strength to its weight, and to its heat-resistant qualities, that it fills a need which no other metal will fill?

Mr. MCCREARY. Better than the other metals, that is right. There are certain applications where it does fill the need better.

Senator MURRAY. Do you know to what extent other countries are engaging in technological studies?

Mr. MCCREARY. No; I am not in a position to comment on that.

Mr. RAYNES. The Air Technical Intelligence has data on that which I am sure is available to you people. They have pretty full data.

Senator MALONE. The testimony has shown already there are certain imports from Japan, and from England.

Mr. RAYNES. I meant from Russia.

Senator MALONE. Any questions?

General METZGER. No.

Senator MURRAY. No.

Senator MALONE. Mr. Raynes, the subcommittee very much appreciates your appearance here. We know you are busy, and I hope that you will hold yourself in readiness to furnish us any further information you think might be helpful. If you have any suggestions at any time, send them to us, either myself as chairman, or any member of the subcommittee. Thank you.

Tomorrow at 10 a. m., in the New York Room, we will hear, first, Mr. William Allen, president of the Boeing Aircraft, and other witnesses following Mr. Allen.

The subcommittee will stand in recess until tomorrow morning at 10 o'clock.

(Thereupon at 4:15 p. m., a recess was taken until Wednesday, November 4, 1953, at 10 a. m.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

WEDNESDAY, NOVEMBER 4, 1953

UNITED STATES SENATE,
SPECIAL SUBCOMMITTEE ON MINERALS,
MATERIALS, AND FUELS ECONOMICS
OF THE COMMITTEE ON INTERIOR
AND INSULAR AFFAIRS,
Los Angeles, Calif.

The subcommittee met, pursuant to adjournment, at 10 a. m., in the New York Room, Statler Hotel, Los Angeles, Calif., Senator George W. Malone, of Nevada, chairman of the subcommittee, presiding.

Present: Senators George W. Malone, of Nevada, and James Murray, of Montana.

Also present: Jerome S. Adlerman, counsel to the subcommittee.

Senator MALONE. The subcommittee will be in order.

Our meeting yesterday was very interesting and very informative on the present and future use of titanium in the manufacture of aircraft, guided missiles, and other war and civilian materiel. Especially I was impressed—and I am sure Senator Murray was—that it is a metal that, if any potential enemy has the metal, what it costs us to get it wouldn't be very important.

The cost and availability and workability of the metal, of course, are problems that we face with every new material. We faced the same problems in magnesium and aluminum and all new material. I understand the first aluminum was $50 or more a pound; at least, we are below that cost.

Then the general indication of all the testimony so far is that, while we are trying to get it for national defense, it is a metal for which there will also be a large commercial demand. What I am saying is that, the chairman, at least, is impressed. All the way from Henderson hearings were held, where they are actually making the metal, and to southern California, where they are actually using the metal in the manufacture of planes. Although at the present time the cost is high, it will be decreased as the volume of manufacture goes up. Already the demand exceeds the supply, and targets for production for the next 5 years are too low.

Some of us remember when we talked about low-cost power, anything under a half cent per kilowatt-hour was low-cost power 25 years ago, and before we knew it all the plans we had made for power were deficient. We never did have enough low-cost power. And that is what is slowing production here.

Yesterday we heard the Douglas and the Lockheed people, and Rohr Aircraft, North American, and Consolidated; and today we have with us the Boeing Aircraft folks, Northrop, Solar Aircraft, and Harvey Machine Co.

If there are any others, when we have finished with those witnesses, whether it is in the production of titanium, or the raw material, or the actual use in industry, we will be glad to hear you. Today will be the last day of the hearing.

I also want to thank and compliment the newspapers. The stories this morning were accurate, and they were very good.

At this time Gen. Oliver Echols, of the Northrop Corp., will come forward. We will hear you first. You may bring anyone with you.

General ECHOLS. Mr. Frank Bolte.

STATEMENTS OF GEN. OLIVER P. ECHOLS AND FRANK B. BOLTE, NORTHROP AIRCRAFT, INC., HAWTHORN, CALIF.

Senator MALONE. General, you were not present yesterday?

General ECHOLS. No, sir.

Senator MALONE. Therefore, I will just tell you briefly the objectives of the committee. First, it is a standing subcommittee of the Interior and Insular Committee made up of five members: Senator Murray of Montana, in addition to the chairman from Nevada, Senator Millikin from Colorado, Senator Barrett of Wyoming, and Senator Clements of Kentucky. Their report and recommendations, findings will go to the main committee, which has 13 members. Senator Butler of Nebraska is chairman, and is in entire sympathy with the work the committee is doing. The recommendations then from the full committee would go to the Senate. The work of the subcommittee, under Senate Resolution 143, to determine the availability of the strategic and critical materials—there are about 77 of these. The subcommittee is responsible for determining the accessibility of these materials for defense and to fulfill the requirements of an expanding domestic economy. It is the first time that the Senate has ever instructed a committee to do this job, and we are really trying to do it.

Now, in the matter of titanium, which is only one—but we consider it a very important one—of the strategic materials, we started at one of the two points in the United States where the material is actually being manufactured, Titanium Corp., in Henderson, Nev. We have not yet heard the Du Pont Corp. that is manufacturing about the same amount per day in New Jersey. But we will hear them later when we return to Washington.

We found upon investigation that contracts, let about 3 years ago, 10 tons per day each, are now up to about 4 tons per day, which is not very fast progress. No blame attaches to anyone. It is new; it is not easy. They are doing the best they can. The committee feels there may be certain places we can help break the deadlock. The raw material rutile now largely is coming from Australia. There is plenty of evidence that there is any amount of the raw material in a little different form, ilmenite, in the United States and Canada, which would be available in wartime.

There are quite a few people who have grave doubts as to whether, in the next all-out war, whether they call it No. III or IV, whether you

are going to get very much across either ocean in surface vessels. This will be another phase of our investigation later, as to what routes can be kept open. But we have no doubt at the moment that we can develop all the raw material we want in the United States and Canada; we have no doubt from what we have heard that all these problems will be whipped. But we have found some pretty real problems.

Now, in coming here, then, there are two things we want to know and want to be helpful in. They are, first, how much of this material are you using at the present time; what luck are you having with it; what are your problems if you care to tell us; what is the status of the work in solving them, research, et cetera. We are talking about amounts of the material that you are actually using. Tell us what you think the future use of the material would be if you could just forget about the availability of the material and the quality, just like you do now with stainless steel and aluminum, and just use it where it will do the most good in the program you now see ahead of you; and if you can visualize, if we actually got into a war, what we would do then.

You can see then what we are interested in; we go back to Washington and coordinate our information after we have finished with the hearings on the material, and the committee will at least be one group that has all the problems.

General ECHOLS. Yes, sir.

Senator MALONE. We are not after anybody, even if they have made mistakes. We are not an investigating committee. We are simply a committee to see if we can further the program to make available in wartime, as instructed by the committee, these materials; and, in this case, titanium.

General, if you will identify yourself for the purpose of the record and identify your associate, and just take your own time and method and tell us whatever you care to have in the record?

General ECHOLS. Yes, sir. My name is Oliver P. Echols, president of Northrop Aircraft.

My assistant is Mr. Frank Bolte, and he is in charge of our materials development and testing.

In regard to the use of titanium and its prospective use, I think we feel very strongly—I believe most of the other aircraft manufacturers do—that, you might say, it is practically essential in the use of combat supersonic airplanes. We believe that most all combat airplanes will be supersonic in the very near future, and the demand for it is, at a rather early date, we consider, imperative.

In making any estimates as to the quantities, it is simply based on our present situation, we hope that it probably would continue as is. We could see a demand in probably 4 or 5 years for us of, say, about 250 tons; that is, of the raw material. I believe the finished product would be one-half of that.

Senator MALONE. This will be annually?

General ECHOLS. Yes, sir. In the present use of it, we are not using it in our production airplanes. We couldn't because it hasn't been designed into them. But we are using it experimentally for future airplanes, with the hopes of having it.

We were thinking that probably some 20 percent of the airplane would be titanium, and that possibly that would be increased as time went on.

Senator MALONE. Availability and workability of the material?

General ECHOLS. Yes. We can see a figure maybe as high as 40 percent. Just at the present time we are using it experimentally, and the extent to which we are using it is still dependent somewhat on its availability, plus the experimental work that we have, where we could use it.

I will ask Mr. Bolte to tell you, because he is handling it, just exactly what we are doing and what our present experience is with it.

Senator MALONE. One of the reasons that we are going into this as far as we are, we could see the lag between the plans for production and actual production—3 years ago contracts were let—and then I wanted to ask you how much of a lag is there between the availability of the material, that is to say, when you can see your way clear to take the plans off the board, know you can depend on it, until the plane is in the air, or until it is usable?

Mr. BOLTE. Approximately 2 years.

Senator MALONE. If you knew today that you didn't have to worry about the availability of the material, it would merely be a question of the practicability of its use, then in 2 years from now you could have a plane in the air that had all the titanium in it that you thought would be successful with your experience in using it?

Mr. BOLTE. That is correct, if we could get the titanium. It is in short supply.

Senator MALONE. The reason I am trying to arrive at that is because we need, when wet get back, to know how important it is to try to speed that up, and if you could depend in a year from now or 2 years from now that you had it all, then you would have to start your 2 years from there, is that correct?

Mr. BOLTE. That is correct.

Senator MALONE. Go right ahead.

EXCLUSIVE CATEGORY

Mr. BOLTE. The real need for titanium is caused by two basic facts. One is increased engine temperatures for higher thrust; the areas around the engines are becoming hotter. The other need for it is the fact we are going to fly much faster, which will create temperature rise in the skins of the aircraft themselves, which will exceed the physical properties of aluminum alloy. Titanium fits in the middle between aluminum alloy and steel, weightwise, strengthwise. It is probably the only known material that will get us through these future requirements.

Senator MALONE. That in itself is a very important statement. Don't you think so?

Senator MURRAY. Yes.

Senator MALONE. It is the only known material you can pass these speeds with.

Mr. BOLTE. I think that sums up our requirements. We probably will use in the current design aircraft, which will be built within 2 years, in the neighborhood of 20 percent weightwise of the airframe, and we can see 40 percent or better in other aircraft, weightwise of the airframe.

Senator MALONE. Forty percent, you think, regardless of its availability, or workability, would finally be about the top percent?

Mr. BOLTE. It could exceed that.

Senator MALONE. How much do you suppose, just guessing or looking ahead?

Mr. BOLTE. I didn't bring my crystal ball. We are not in that design stage yet.

Senator MALONE. The reason I am asking you is that I think we have reached the grassroots, and we are talking now to the people who could make the best guess. The reason we asked Titanium Corp. as to what they could do in production is because they are right there taking the raw material, turning out titanium, and therefore, they could make the best guess in that regard. You can make the best one here. Maybe it will be wrong; maybe it will be right. But it will be better than ours.

Mr. BOLTE. Let's look at it this way: Materials are used where they are best suited. You can't build an entire airplane out of titanium. You will have to use steel. You will have to use some forms of aluminum alloys, some forms of plastics, and other things such as that. The figures I gave just a minute ago, I think, are about as reasonable as we can quote at the moment. Anyone that says you can build an entire glass airplane or ceramic airplane is wrong. You have to use these materials only where they are required, and if we use titanium intelligently, we will use it only where it is required.

Senator MALONE. That is correct. You think you might eventually use near 50 percent?

Mr. BOLTE. It might approach that figure; yes.

I think I have summed our position up fairly well. Those are the facts.

Senator MALONE. The 40 percent which you can see now, if you had had it 2 years ago, if you would have gotten all you wanted the 2 years from then, how much titanium would you be using now, on the 40-percent basis, if you had had all you wanted 2 years ago? You know what you are doing. That would constitute future use.

Mr. BOLTE. Probably using about 20 percent now of the airframe weight.

Senator MALONE. Forty?

Mr. BOLTE. Twenty percent.

Senator MALONE. You are now.

Mr. BOLTE. No; we are not now. We did not have it available at the time of the design of our current aircraft.

Senator MALONE. The 20 comes before the 40, and it is all in the future?

Mr. BOLTE. Yes.

Senator MALONE. What would you be using on the 20-percent basis?

Mr. BOLTE. Pounds per month?

Senator MALONE. Per year. Don't go into too much detail. You are subject to correction if you want to send in a letter later.

Mr. BOLTE. In sheet material, raw stock delivered, someplace in the neighborhood of 200 tons per year.

Senator MALONE. That you would be using?

Mr. BOLTE. We would be using, had it been available.

Senator MALONE. What percentage of the aircraft do you think you are manufacturing—I am trying to get at then what the total use might be.

Mr. BOLTE. This percentage that I have quoted here is for airframe alone, not engine use. The engine manufacturers are contemplating

quite extensive use of titanium in compressor blades and other sections that are hotter than the aluminum alloys and the magnesium can stand in the engine. I do not care to state figures on the engine manufacturers' requirements. That should come from the engine people themselves.

Senator MALONE. Who are they?

Mr. BOLTE. Pratt & Whitney, Wright Aeronautical, General Electric, Lycoming, Allison, Continental, Boeing.

Senator MALONE. The supply you are getting now, is it satisfactory in quality, and are you getting it on time, the amount you want, that is, the amount you have been led to believe you could get?

Mr. BOLTE. We are having difficulty obtaining experimental material. The pure titanium as such in sheet form is satisfactory for the physical properties that it will give you for shrouds and such things as that. The alloys are not satisfactory as yet. There is only one sheet alloy that is usable in today's design. I think that we will have marked improvements in the alloys for sheet in the very near future.

Senator MALONE. What percentage roughly do you have to reject of the material you get, both in the pure and then in the alloys?

Mr. BOLTE. That depends on who produces it.

Senator MALONE. Does it?

Mr. BOLTE. Yes.

Senator MALONE. That is interesting, too. Either from Titanium Corp. or from Du Pont Co.?

Mr. BOLTE. Correct.

Senator MALONE. Which is the best?

Mr. BOLTE. I'm on the spot.

Senator MALONE. Well, you understand you don't have to answer anything you don't want to. I realize that might not be a fair question.

Mr. BOLTE. Thank you, sir.

Senator MALONE. We have to find out. We have not listened to Du Pont's story yet; we have to Titanium Corp., and that is one place where a congressional committee or Senate committee, if they care to, can be helpful, because we don't owe any of them anything. When we are convinced a material is necessary, we want to know what we can do to break any logjam. And I think you will find that the committee is in it for that alone, because it looks like it is an indispensable war material, and very profitably can be used in commercial planes.

Mr. BOLTE. Correct.

Senator MALONE. So leave it to the committee to insult anybody who needs insulting. You give us all the information you can.

SPONGE MUST BE PURE

Mr. BOLTE. I think one thing is very important in the production of titanium sponge. I think that the purity of the sponge is of utmost importance. If it is not pure sponge, no satisfactory alloy can be made from it.

Senator MALONE. In other words, if it is not pure sponge, then it is just out, as far as alloys are concerned?

Mr. BOLTE. Correct.

Senator MALONE. It can be used if it is not too impure in what you call pure material?

Mr. BOLTE. With reservations, that is correct, because, say, too much oxide in the sponge will create severe forming problems.

Senator MALONE. You mean in shapes?

Mr. BOLTE. Yes; that is right.

Senator MALONE. Pressing into shapes?

Mr. BOLTE. That is right.

Senator MALONE. Well, then, what you are up against now is two propositions. One is, the material is scarce; the next is that it is not uniform and all workable?

Mr. BOLTE. Correct.

Senator MALONE. So you are having problems of trying to work material that doesn't quite meet specifications?

Mr. BOLTE. Correct; in fact, some of the best sponge being produced today is coming from Japan.

Senator MALONE. Do you know how much sponge is coming into the country from Japan?

Mr. BOLTE. No.

Senator MALONE. We can find that out from other sources. But it is good sponge?

Mr. BOLTE. Yes.

Senator MALONE. Meet specifications, uniform?

Mr. BOLTE. Yes.

Senator MALONE. The Japs are good workers. One of the difficulties, and you can't object to it as long as they are producing the best, they get 15 cents an hour, and our boys get $1.80. So it makes it a little rough. But if they are producing the only perfect sponge——

Mr. BOLTE. It is not the only perfect sponge; it is good sponge.

Senator MALONE. Isn't there some sponge coming from England, or some material coming from England?

Mr. BOLTE. Very little. England is way behind on this program.

Senator MALONE. A part of Titanium Corp.'s material goes to their parent company. After shapes are manufactured they are being shipped to England?

Mr. BOLTE. That is right.

Senator MALONE. We have not found out yet how much. Do you know?

Mr. BOLTE. No. I have no means of getting that information.

Senator MALONE. We will find out. But those are the things we want to know. Anything further you think will be helpful to us?

Mr. BOLTE. I think I have expressed about all of the views that are important as far as we are concerned. Anything else would be slightly redundant, I believe.

Senator MALONE. That may be true.

General, do you have anything further to add?

General ECHOLS. No, sir; I have not.

Senator MALONE. What percentage of the material that is furnished you has to be rejected in the beginning?

Mr. BOLTE. That depends again on the producer.

Senator MALONE. We will call them producer No. 1, 2, and 3. You don't have to name them.

Mr. BOLTE. Producer 1 has their product to a position—and this is in sheet stock I am talking about—that there are practically no rejections any more.

Senator MALONE. Is that Japan you are talking about or American?

Mr. BOLTE. American. All right. Producers 2 and 3, let's say, have not submitted enough material for fair evaluation in the form of sheet.

Senator MALONE. Well, just roughly, what would you say is the percentage of rejections? That is important for us to know, to know what the problem is.

Mr. BOLTE. In producer 1 the percentage is negligible. The rest have not submitted enough samples for us to make a fair evaluation.

Senator MALONE. But you can see there would be quite a percentage of rejections?

Mr. BOLTE. It could be possible.

Senator MALONE. I had almost forgotten about our scrap problem as far as you are concerned. We are very much interested since we find that the scrap is practically unusable. There is a problem there. What do you do with your scrap?

Mr. BOLTE. One producer has created a system whereby it is possible to recover a high percentage of scrap if it is handled satisfactorily in the shops that are producing it, and not contaminated.

Senator MALONE. How do you mean "not contaminated"?

Mr. BOLTE. Not mixed with other metal scrap or other aluminum alloy and steel and such things.

Senator MALONE. Someone mentioned oil.

Mr. BOLTE. The oil contamination is easily removed; the problem is to get it back into a form that can be used satisfactorily mixed with the sponge.

Senator MALONE. It has to be the pure scrap?

Mr. BOLTE. That is correct.

Senator MALONE. Then they have a way of utilizing it?

Mr. BOLTE. They do. It is not entirely satisfactory as of the moment, but it will be perfected, I am sure. The recovery dollarwise for the price that you pay for the sheet is rather small.

Senator MALONE. What do you get for the scrap?

Mr. BOLTE. I would have to ask our purchasing department.

Senator MALONE. Approximately. Two dollars, a dollar and a half a pound?

Mr. BOLTE. Around that figure.

Senator MALONE. Someone testified yesterday a dollar-ninety per pound.

Mr. BOLTE. Between a dollar and a half and $2.

Senator MALONE. That is good enough. That is a far cry from $20 a pound, but still it is something.

Mr. BOLTE. Correct. It will probably aid in production of the material.

Senator MALONE. Be added material?

Mr. BOLTE. Yes.

Senator MALONE. What company is it that can use this scrap to advantage now?

Mr. BOLTE. Rem-Cru.

Senator MALONE. Do you think or have you heard them talk enough about it so you can say as to this: Is there in the reasonably near future

a possibility that the scrap could be utilized like steel scrap and aluminum scrap and other scrap that is just thrown in and utilized, or is it always going to be an expensive reclaiming process?

Mr. BOLTE. With the now known methods of producing titanium in the metallic form, it is going to be difficult.

Senator MALONE. It is always going to be expensive so there would be a wide spread between scrap and material?

Mr. BOLTE. Correct.

Senator MALONE. Senator Murray?

Senator MURRAY. It seems to me that the testimony given is quite clear and understandable. I don't see that there are any questions that I could ask.

Do you sell the scrap to some particular company or do you return it to the producer that you got it from and get a credit on it?

Mr. BOLTE. The plan is to return it to the producer.

Senator MURRAY. Then when you buy additional supplies, they give you credit on it?

Mr. BOLTE. Correct.

Senator MURRAY. I don't think I have any more questions.

Senator MALONE. General, of course, this gets into the question again of price. Yesterday there was much testimony offered as far as national defense is concerned. Price was practically no drawback, and on certain parts of the plane regardless of the price, it had to be used. Suppose this sponge would be reduced from $5 to $4 or $3; with the rolling probably cheapened, accordingly, after experience, and perfecting the sponge material, the specifications, that is, running uniform, and in the shapes, could you give us some idea of what the price has to do with what you would do with it? We know it is high priced now.

General ECHOLS. That is terribly difficult to say. As you know, the price of aircraft is one of the things that the Government, as well as ourselves, is fighting against all the time. But you do get into a situation which involves military requirements. To sell your airplane at all, you have to attain a certain performance, and sometimes to attain that performance you have to use the materials they give to you.

I think the belief is that, as stated by Mr. Bolte, when we get into a certain place, which is relatively in the near future in regard to performance, that titanium is now the only metal we know that will suffice, and if it is available and if we are to get the performance, I think we would have to use it.

Senator MALONE. Regardless of price?

General ECHOLS. I am afraid so.

Senator MALONE. There are certain parts of the plane though, when you get up to your 50 percent or even above that amount in a commercial plane, you might or might not use it on account of price?

General ECHOLS. That is right.

Senator MALONE. Just give us whatever you feel you can. We know you are getting into conjecture there.

General ECHOLS. We feel when we get to a certain point that this 20 percent is a must.

Senator MALONE. You are talking about a——

General ECHOLS. The military plane.

Senator MALONE. Regardless of cost?

General ECHOLS. Yes, sir. I am not qualified to discuss the commercial aspect of it, because there the performance plus the cost is much more important.

Senator MALONE. Payload?

General ECHOLS. The airline operator has to pay his way, and it is a question of what the public will pay for performance. But in the military airplane, inferior performance is just not permissible.

Senator MURRAY. As the price would come down as a result of development, it would have a far wider use, wouldn't it?

General ECHOLS. It would.

Senator MURRAY. Just like aluminum when it was first produced; it was very expensive, and now we are using it to put roofs on barns.

General ECHOLS. Yes, sir. I hope we can foresee that same experience in titanium. When we first used aluminum in aircraft, it was very expensive, and as it became available and the demand increased and the supply increased, they began to match each other, and it has become a very economical metal.

Mr. BOLTE. May I comment on that? The cap on the Washington Monument was made out of then a very expensive metal, aluminum.

Senator MALONE. They do say, don't they, that Napoleon had a dinner service made out of aluminum rather than gold because it cost more? [Laughter.]

Well, go right ahead, Senator. It is just one of those things.

Senator MURRAY. I think I have asked all the questions I care to ask. I think the testimony they have given us is quite clear and understandable. I don't see the need of asking them any further questions.

Senator MALONE. They do say that the mineral is one of the most plentiful minerals in the earth's surface, so apparently there is no question about raw material, and there are certain fixed charges; it was testified at Henderson that from 16 to 23 kilowatt-hours per pound were used in electric power, depending upon what was included in the process. That proved that the price of the power was not as important in $5 a pound as I had originally though it might be. So there does seem plenty of room for reductions. Therefore, it must come back to the point of volume resulting in a lower price after the material is perfected. The trick is to get the volume started.

Mr. BOLTE. Maybe I should comment on that. All sheet materials that have been produced today have been produced on rolling mills that were designed for steel. I think that our greatest reduction in price in titanium sheet will possibly come from mills that are designed for rolling of titanium.

Senator MALONE. In other words, when there is enough titanium to roll and to go into the appropriate rolling equipment, then there will be a reduction?

Mr. BOLTE. Correct.

Senator MALONE. That sounds reasonable.

General, I know you are right in the middle of all this business at Wright Field, and the committee especially requested you to be here, because there would be chinks in our information that you might fill in.

About the use related to the price, which is going to be important for the committee, because we want to know what stand to take on it when we finally come down to the showdown, could you help us?

General METZGER. At the present time, in utilization of titanium in our aircraft, we are confronted generally with substitutions. Very few of the current aircraft, as has been testified to at this hearing and others, have been designed for the application of any considerable quantity of titanium. Obviously, that has been impossible, in that titanium has not been in sufficient quantity nor of long enough life to enable it to be engineered into current aircraft. So we are dealing generally in the area of substitutions. When we talk about substitutions, it is generally, as has been testified to, substitution of titanium for stainless steel.

Now, due to the substantially increased cost of titanium over and above stainless steel, we in the Air Force have carefully evaluated the military advantage, the advantage to the aircraft, characteristics, performance, speed, range, et cetera, through the substitution of titanium for stainless steel. In other words, we are very anxious to secure proper return for dollar spent.

In the particular instance of General Echols here, in his current fighter, he has an application for titanium to replace stainless steel in that fighter which we cannot approve, and we have not approved it. It is not a military advantage, in other words. It is marginal. It does not increase the performance of the aircraft to an extent that it warrants the expenditure of these additional funds.

Senator MALONE. Reduction in price would immediately make a difference in your attitude?

General METZGER. It very definitely would. It is marginal now. If the cost of titanium were half its present cost, it might be to our advantage to approve that application.

Senator MALONE. Then you are always right up against the iron as to determine where you break over and use it, and the cost is a part of your consideration?

General METZGER. Very definitely, sir; and particularly at this time where we are dealing in substitutions.

Senator MALONE. You have heard all of the evidence so far. We appreciate very much your attendance, and your own testimony at Henderson. We hope you can be in Washington when we hear the du Pont Corp. and some other companies that want to get into the business.

Do you have the feeling that with volume will come a definite, substantial price reduction?

General METZGER. I believe, Senator, that the old law of supply and demand will have its effect on titanium, the same as on any material or any product. And as long as it is in short supply, I don't believe we will see any substantial price reduction.

Senator MALONE. You are talking now about people who are able to manufacture it. But what I mean is suppose that the volume became equal to the demand and that it was just a question of building new production plants, and other people would want to get in the business just like they did in the steel business, and the volume was there, and then it became a matter of competition for the market; what might happen then?

General METZGER. I believe unquestionably there will be a price reduction under those conditions.

Senator MALONE. Substantial?

General METZGER. Substantial. I really do. I think titanium has possibilities, not only in defense weapons or in defense production, but also in commercial production, to the extent that it is a coming metal, and it will find a very firm, permanent place in our metallic field. As such, it will undoubtedly follow the pattern of any other metals which we have had and which we now have and use, and we will reach it in price on the market, which will continue to attract additional applications and uses.

Senator MALONE. I was agreeably surprised when it developed in the hearings in Henderson that the fixed charges were not so high. I had believed for some reason that power cost was quite a factor, but considering 20 kilowatt-hours, and they are getting power at Henderson around three, 3½ mills per kilowatt-hour, that would mean only about 6 or 7 cents a pound for power.

Other fixed charges were testified to there, someone testified that the sponge cost might be cut in two within a reasonable time, and the other costs accordingly.

Do you remember the testimony?

General METZGER. Yes.

Senator MALONE. Do you believe they have a point there?

General METZGER. I really do believe that.

Senator MALONE. That is the important thing.

General METZGER. I believe not only will the reduction in the cost of sponge effect or influence a lower price of mill products, but the actual reduction in cost in the production of mill products will influence a lower end-product price.

Senator MALONE. Domestic production of the raw material after it is properly coordinated perhaps might have some effect?

General METZGER. Yes, sir.

Senator MALONE. Aluminum, of course, started out at—somebody has said $50 a pound. It is now down to cents where it was dollars before.

General METZGER. Yes, sir.

Senator MALONE. And that has come about because of the great demand for aluminum, and pretty near anybody can make aluminum if they can get the power and raw material.

General METZGER. Magnesium is a good example. It is a little bit newer as a structural material than aluminum. If I recall, roughly, magnesium has dropped from $5 a pound to 27 cents in less than 20 years.

Senator MALONE. Doesn't a special demand make a difference in time element? In other words, if we had no emergency and there was no threatened war and we were taking our time, and these men were out here competing in commercial planes and were not pressed for warplanes, it might take 20, 30 years to get this metal in general production. But don't you suppose that, like magnesium—magnesium was a very scarce article, and right there at Henderson, Nev., during the war was the greatest magnesium plant in the world, built almost overnight, cost being no consideration—now, since cost is no consideration as far as the necessary part of a warplane, isn't it reasonable to suppose that with the Bureau of Mines, and with many other private laboratories run by experienced and large companies, knowing there is a great reward at the end of the rainbow, isn't it reasonable to suppose in a very relatively short time this might come about?

General METZGER. I believe it will, sir. I think it is very reasonable to believe that.

Senator MALONE. General, you can see what we are trying to find out. If you have any further statement now, we would be glad to have it. If you do not, if you think of anything after you get home that you think would be helpful to the committee—I want you to know that we want to be helpful—if you would just write either the chairman or any member of the committee, Senate Office Building, and give it to us—if it is classified, let us know; we can get it in some other manner—we would appreciate it.

General ECHOLS. Yes, sir. Thank you very much. I have no further statement to make.

Senator MALONE. Thank you, General.

At this point in the record, we will have included in the record a table, "United States exports of titanium, ilmenite, and rutile (exports of United States merchandise except as indicated)."

YEAR 1952

Schedule B number	Commodity and country	Quantity in pounds	Value in dollars
664570	Ores and concentrates, domestic	1,739,749	$110,737
	Canada	1,733,137	110,367
	Hong Kong	6,612	370
	Ores and concentrates, reexports	138,500	6,389
	Canada	138,500	6,389
664571	Metal and alloys in crude form and scrap	1,524,923	31,134
	Canada	1,520,037	12,409
	United Kingdom	1,256	16,905
	France	1,390	700
	Italy	2,240	1,120
664573	Semifabricated forms	6,910	38,979
	Canada	2,092	21,211
	United Kingdom	340	5,453
	Belgium	4,478	12,315

JANUARY-JUNE 1953

664570	Ores and concentrates [1]	1,778,691	75,796
	Canada	1,722,191	71,443
	Mexico	23,500	2,749
	France	22,000	374
	Hong Kong	11,000	1,230
664571	Metals and alloys in crude form and scrap	2,139,074	20,206
	Canada	2,136,564	15,447
	United Kingdom	270	2,815
	Belgium and Luxembourg	2,205	1,388
	West Germany	30	375
	Japan	5	181
664573	Semifabricated forms	39,684	505,398
	Canada	57	1,134
	Sweden	384	5,030
	United Kingdom	39,237	499,057
	West Germany	6	177

[1] There were no reexports of ores and concentrates for the period January-June 1953.

Source: Prepared in the Department of Commerce, by International Economic Analysis Division, Bureau of Foreign Commerce, from basic data of the Bureau of the Census, October 1953.

Senator MALONE. Mr. Hitchcock, we are very glad to see you here. We have been familiar with the work of Boeing Airplane Co. for many years. As a matter of fact, it seems to me the first plane I rode across the Nation in, in 1927 or thereabouts, was a Boeing plane; just had room for two passengers back of the mail. Pilots were out of World War I. That happened to be my war too. They would read novels after they go up in the air, and across Kansas one time I kidded the pilot a little. I accused him of having to come up to go over the trees, and one time not long after then, one of them hit a tree and burned up in Kansas.

But Boeing, like Douglas, Lockheed, and North American has been right up there in front all the time. We are glad to see you here. You already know the objectives of the committee. If you will identify yourself for the record, and just in your own way give us as much information as you think would be helpful.

STATEMENT OF L. M. HITCHCOCK, STAFF ENGINEER IN CHARGE OF STRUCTURES, ENGINEERING DIVISION, BOEING AIRPLANE CO., SEATTLE, WASH.

Mr. HITCHCOCK. L. M. Hitchcock. I am staff engineer in charge of structures of the engineering division of the Boeing Airplane Co., Seattle, Wash.

GREAT HOPE FOR TITANIUM

I have a number of figures here.

Senator MALONE. Proceed in your own way.

Mr. HITCHCOCK. I would like to emphasize, first, that at this stage of the game we are not using very much titanium. As a matter of fact, the only use at the moment that we have is commercially pure sheet in the nacelle structures of the B–52 and B–47. We have great hopes for titanium, and we anticipate using a considerably larger amount in the next couple of years, as the alloys are developed. Right today we don't have alloys available which are competitive from a strength-weight ratio with aluminum alloy for subsonic airplanes.

Senator MALONE. When you say "subsonic airplanes," do you mean under the speed of sound?

Mr. HITCHCOCK. Yes.

Senator MALONE. 500 or 600 miles an hour, up to that point?

Mr. HITCHCOCK. Yes. As we get into the supersonic airplanes, titanium—if we have alloys developed—we believe will be a better material than aluminum alloy or steel.

Senator MALONE. Would aluminum alloy suffice when you pass those speeds at a great amount?

Mr. HITCHCOCK. No. I don't know whether anybody has ever shown you one of these curves or not, but here is the picture of what happens. The top curve shows the skin-temperature rise. Down below is shown equivalent speed in miles per hour. So that here is a plot of the relative strength of materials as compared to the strength of aluminum alloy at room temperature.

Senator MALONE. Titanium holds up to 2,500 miles an hour and then steel takes over?

Mr. HITCHCOCK. Yes. That also demonstrates the fact that, until we do get the titanium alloys developed, we can build airplanes in the intermediate speed range out of stainless steel. However, there would be a penalty in performance over what we could possibly realize out of titanium.

Senator MALONE. How does the strength of stainless steel and titanium compare in a weight ratio, that is, a pound of titanium; same weight of titanium and steel; what is the relative strength?

Mr. HITCHCOCK. Well, what this curve shows is the actual strength-weight ratio.

Senator MALONE. Explain it for the benefit of the record, and then we will make it a part of the record.

This is the first time we have seen the chart, and many will see it that have not seen many charts.

Mr. HITCHCOCK. Well, this chart shows basically a plot of a titanium alloy, a stainless-steel alloy, and an aluminum alloy, and it shows that at the lower speeds or the lower temperatures that titanium alloy is the best material from a strength-ratio standpoint. If we had the titanium alloys today that we think we are going to have in the future, they would compete very definitely with aluminum alloy.

Senator MALONE. If you had had the material, say, 2 or 3 years ago so that you could take anything off the drafting board with any amount of titanium that would be of the greatest service or meet the specifications that you had to meet, then you would be using much of the titanium at the present time instead of either steel or aluminum alloys; is that the thing you have tried to say there?

Mr. HITCHCOCK. If the price were right, yes.

Senator MALONE. You are talking now about commercial planes?

Mr. HITCHCOCK. Well, yes.

Senator MALONE. Or war planes as explained by General Metzger?

Mr. HITCHCOCK. Yes; that's also right. Basically, this curve shows that you can build the lightest structure to carry a given load with future titanium alloys up into a speed range of close to 2,500 miles an hour.

Senator MALONE. That would be then where the titanium took over, at 700 or 800 miles an hour up to 2,500, in that interval, the titanium would do the job better?

Mr. HITCHCOCK. Yes. And I am also saying that, even in the lower speed range, if we had the titanium alloys today and the price was right, that we would use it many places where we now use steel or aluminum.

Senator MALONE. If you have an idea about the price, where would the price have to be before it would take over under the 700 or 800 miles an hour, in the subsonic speeds?

Mr. HITCHCOCK. Oh, I would just estimate that maybe $5 a pound for military and maybe $2 a pound for commercial, something of that order.

Senator MALONE. Now you are talking about the finished material, which would be quite a reduction?

Mr. HITCHCOCK. Yes.

Senator MALONE. Now, about $15 a pound for the plate; rolled plate; and $5 a pound for the sponge alone. But if it were $5 overall, you would be using a great amount of it?

Mr. HITCHCOCK. Yes. That is just an estimate on my part.

Senator MALONE. Go right ahead.

BIG FIELDS IN ALLOYS

Mr. HITCHCOCK. Well, what I was trying to emphasize—and I suppose that it has been emphasized many times—is the fact that the titanium alloys are in the development stage. When and if they become available, with the physical properties we think can be developed, 160,000 p. s. i., 170,000 p. s. i., titanium alloys, then we are really going to use a lot of the material. We have very small usage for the commercially pure material. The large usage is going to be from alloys, when and if they become available.

Senator MALONE. They are stronger and lighter?

Mr. HITCHCOCK. Yes.

Senator MALONE. You have heard the testimony here this morning. Is there any metal really competitive with titanium in the field you are describing at the moment? When I say "competitive," I mean is it a metal that you have to have under certain conditions?

Mr. HITCHCOCK. Well, I would say that for the supersonic application that it is a metal that is very necessary. You could build airplanes out of stainless steel, but at a sacrifice in performance.

Senator MALONE. Which is bad in a warplane, anyway.

Mr. HITCHCOCK. Yes, that is correct.

Senator MALONE. Well, you are in the commercial-plane business and have been from the beginning. We had some testimony as to what a pound in the original design, saved in the original design, meant in a finished plane. Could you give us any information along that line?

Mr. HITCHCOCK. Well, you could get any number from what a pound of weight saved is worth, a number anywhere from $20 a pound to a thousand dollars a pound. You can choose any number you wish. Everyone you talk to will quote a different number.

As far as commercial airplanes are concerned, I would guess $25 a pound to possibly $40 a pound would justify a pound of weight saving.

Senator MALONE. Then there was some testimony which I originally had reference to; that if you saved a pound of weight in the original design, in the structure, then it saved something like 7 or 8 pounds in the finished plane due to wingspread, strength of landing gear and engine drive, power, and various things. Would you have any remarks to make about that?

Mr. HITCHCOCK. Well, for a pound of weight saved in an airplane—we have recently quoted numbers of saving on total airplane weight of 9 to 10 pounds.

Senator MALONE. Explain that for the record a little more, if you will.

Mr. HITCHCOCK. Well, if you save a pound, let us say, in an item of equipment or in an item of airframe, the overall weight of the airplane will be decreased in the order of 9 to 10 pounds.

Senator MALONE. Due to these various weight factors in other parts of the plane?

Mr. HITCHCOCK. Yes.

Senator MALONE. Give us a little further explanation of that, those factors, if you will.

Mr. HITCHCOCK. Well——

Senator MALONE. You don't need quite so much power in the engine; your landing gear won't be quite so heavy; your wingspread and all that. I am not in the business so I can talk freely. You are in the business and have to be right.

Mr. HITCHCOCK. There are many variables in that, but you are absolutely correct. As you save weight in the airplane, of course, the wing does not have to support as much airload. Consequently, the wing structure is lighter. As you reduce the weight of the wing structure, you reduce the weight of the airplane, which results in reduced weights of the landing gear; also requires less engine thrust to get a required amount of performance. There are just many factors which result in the fact that weight saving does have a large influence on the final overall weight of the airplane.

Senator MALONE. That, then, begins to get into the economics of your commercial plane?

Mr. HITCHCOCK. Yes.

Senator MALONE. That is where the effect comes?

Mr. HITCHCOCK. Yes.

Senator MALONE. And in warplanes it is a matter of speed and amount of fuel it can carry, and all that might make the difference between a pilot getting home and not getting home or winning a fight?

Mr. HITCHCOCK. Yes, of course, range is a very important item.

Senator MALONE. Go right ahead if you have other testimony.

WARTIME PRODUCTION

Mr. HITCHCOCK. If we were in wartime production like we were in the last war, when we turned out a billion pounds of airframe weight in 1944——

Senator MALONE. A billion pounds?

Mr. HITCHCOCK. A billion pounds of airframe weight in 1944.

Senator MALONE. This is all manufacturers?

Mr. HITCHCOCK. All manufacturers within the United States, military and commercial, although, actually, at that time I don't believe there was any commercial business. The actual requirements on sponge, putting in suitable factors for scrap lossage and the fact that the finished material is about half the weight of the sponges are quite high. If we were going to produce a billion pounds, say, of airframe weight in 1956, we would probably require about 200,000 tons of sponge.

If we were going to do that, say, in 1959 or 1960, and we had suitable alloys in forging, sheet, extrusions, bar, plate, tubing, that number could very well be 400,000 tons or more.

One of the factors influencing that, of course, would depend upon how much airframe weight we were producing which was of the supersonic variety, say, up in the 1,500- to 2,500-miles-per-hour class. So those numbers are just more or less guideposts as to what might be the demand.

Those numbers have some factors in them; for instance, in 1956 we would have a much higher factor for scrap loss than we would have, say, in 1960, when we become more familiar with the handling of the material.

Well, those are just some ideas on what might come about if we were in an actual war.

Senator MALONE. I appreciate what you are saying, for the reason that here we are; for many years we are told we are on the verge of a war, which this time would be really something, and probably be conducted entirely different from either one of the other two world wars.

Someone who is experienced—that is the reason the committee is here—must do the talking. We have nothing to go by personally, and people not in the business can only talk from hearsay. But you were in this business during World War II. You were in it in World War I when we did not turn out many planes, but we certainly saw the need. I think we had one plane with each battery field artillery, and they would go out and look at the target and come back and tell us where we hit.

Mr. HITCHCOCK. See how you were doing?

Senator MALONE. Sometimes we weren't doing very well. But World War II was an entirely different thing, and some of us think world war III or IV, whatever we call it, is going to be entirely different from even World War II. So you are, as you say, estimating in a field that needs estimating, because, in the first place, each one of the airplane companies is getting certain contracts from the Air Corps, as General Metzger has so well outlined. But the minute you really pull the pin and you go all out again, it seems to some of us what we need to do in the interim is to be ready to do what you are just talking about. So it goes right back to the raw material, and the contracts for production of the material, and trying to not only increase the volume but decrease the price.

Now, in this 200,000 tons that we might use in 1956, if we turned out 1 billion pounds frame weight on a wartime basis, what percentage of titanium would be included in those frames?

Mr. HITCHCOCK. Well, what we had figured was around 6 percent of the airframe weight, and we had a figure on top of that of scrap loss due to forging, due to machining of fittings and normal scrap lossage involved in making parts out of sheet; as we understand it, on our experimental procurement of titanium forgings, it requires today about 4 pounds of titanium to forge one pound of finished product. And scrap losses in sheet, of course, when we are unfamiliar with a material, can well be 50 percent, or the end product is only one-half of what you actually buy. There is an additional factor there too between the finished ingot and the sponge. We actually had a figure there of the actual weight of the parts in the airplane would be multiplied by 3½ to account for material losses due to machining and forging and other scrap losses, plus a factor of 2 in converting the sponge. In the figures quoted, say, for 1959 or 1960, we reduced the factor of 3½ to 1¾. Those are purely estimates. Whether they are right within a hundred percent, I don't know. I could give you some additional information here as to what Boeing thinks they might be using in 1956.

Senator MALONE. We would be very glad to have that information, and I think the information you have already given us is invaluable because we have reached the point now beyond which we cannot go. There is no one who can make a better guess, in our opinion, than someone who has been actually making the planes.

Mr. HITCHCOCK. I would like to emphasize that they are all based on 1 billion pounds of airframe weight. If we get into an actual war where we will produce 500 million or a billion and a half or some other number, or course——

SCRAP VALUE WILL INCREASE

Senator MALONE. You have a reference to go by, anyway. Go right ahead. I was going to ask you about the scrap. In the testimony we have had all the way through, the scrap runs all the way from a total loss to a recovery of maybe 5 to 10 percent of cost. What do you think about this scrap business? Will there be a notable improvement in the value of the scrap as time goes on?

Mr. HITCHCOCK. Oh, very definitely. For any new material when you first start working with it, a scrap loss of 50 percent or more is possible. As you get familiar with the material your scrap costs gradually will decrease to maybe 10 or 15 percent.

Senator MALONE. The material is more uniform?

Mr. HITCHCOCK. The material is more uniform, and people are familiar with handling it, working with it, and fabricating it.

Senator MALONE. The scrap itself might become more valuable due to better methods of reclaiming, might it not?

Mr. HITCHCOCK. Yes, although, frankly, I don't have any information on the reclamation of titanium scrap.

Senator MALONE. Go right ahead with your other statement.

Mr. HITCHCOCK. Well. as far as Boeing is concerned, in the production of B–52, B–47, C–97 airplanes, we feel in 1956 that we will probably require 7,000 tons of sponge. Those numbers are based on a thousand tons of finished product multiplied by a factor of 3½ multiplied by a factor of 2 for converting sponge to the ingot.

Our present usage of titanium on the B–57 and B–47 is very small. We are only using it now in the power packages and the engine struts.

Senator MALONE. Is that because you did not have the assured supply when you took the planes off the drafting board, to some extent, at least?

Mr. HITCHCOCK. Well, to some extent; but mainly the fact that we do not have the alloys avaliable which will compete, strength-weight ratio, with other materials.

Senator MALONE. You mean, you know that the alloys are available, but not in sufficient amount for you to take a chance on using them, or are they not yet developed?

Mr. HITCHCOCK. They have not been developed to high enough physical properties.

Senator MALONE. But you think they will be?

Mr. HITCHCOCK. We think they will be.

Senator MALONE. Go right ahead.

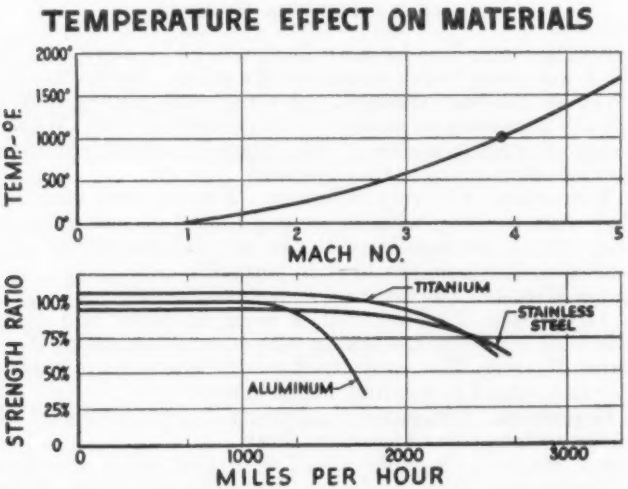
Mr. HITCHCOCK. Well, I don't believe I have anything else to add, unless you have additional questions.

Senator MALONE. Is there anything in your written statement that should be included in the record, that you have not explained?

Mr. HITCHCOCK. No; I don't believe so. This just happens to be one of our internal reports, which I don't think would add anything to what I have already said.

Senator MALONE. I want to make this chart, "Temperature effect on materials," a part of the record at this point as a part of the testimony.

(The chart referred to follows:)



Senator MALONE. I am very much interested in your estimate of the use of titanium in the frames, providing we went all out, as we did once before, in the manufacture of airplanes. You confined your testimony to the frame, and we have had testimony here that, of course, the engine and other parts contain quite a lot of titanium, will under the same conditions. Would you care to estimate, or could you, what additional titanium might be used in the engines and the other parts of the plane if you used that amount of titanium in the airframe alone?

Mr. HITCHCOCK. Well, I think that is probably a question that should be asked of the engine manufacturers.

Senator MALONE. Who are your manufacturers?

Mr. HITCHCOCK. Pratt & Whitney and General Electric; of course, on our future designs we are also working with Westinghouse and Allison and Wright.

Senator MALONE. You have no further estimates to make; you would rather leave that to the people who manufacture the other parts?

Mr. HITCHCOCK. Yes.

Senator MALONE. General, in order to keep up with this business—I do not like to impose upon you when you can always say it is not expedient to answer—but would you have any information that might dovetail with the testimony that 1 billion pounds of airframe might

use 200,000 tons of sponge in 1956 designs and say 400,000 tons or more in the 1958–59 designs? Taking into account the engines and the other parts?

General METZGER. I feel it is significant that the estimate given by Mr. Hitchcock is confined to airframe weight, and the 1 billion pounds was actually the peak production in World War II in airframe weight.

From what we know of the activity among the engine builders in research development of application of titanium in their engines, it is very conceivable that the requirement of the engine builders in a program such as Mr. Hitchcock referred to, 1 billion pounds of airframe weight in a year, the requirement of the engine builders could equal that requirement for the airframe manufacturers. If so, we could roughly double the requirement, as projected, estimated by Mr. Hitchcock. I believe the figures you used were 200,000 tons, possibly reaching 400,000 tons. We could roughly double, taking into consideration the requirements of the engine builders and certain of the equipment manufacturers. There are many equipments installed in airframes which are presently being researched for application of titanium for the same reasons given by the airframe manufacturers; lighter weight, ability to withstand higher temperatures. And the extent to which the demand will be developed for titanium is still an estimate, but I don't think that we would be too far wrong in a program such as we are discussing here to estimate double that requirement.

Senator MALONE. In other words, if it was 200,000 tons in 1956, it could easily in total reach 400,000 tons; and in 1958, 1959, if it was going to be 400,000 tons for the frames, it could easily reach, say, 800,000 tons in total?

General METZGER. It is purely an estimate. I am sure we all understand that.

Senator MALONE. Of course.

General METZGER. But it is within the realm of possibility.

Senator MALONE. Didn't we find, General, in World War II—in World War I we just found out if we had a plane, what we thought we could do with it; we didn't have planes. In World War II didn't we suddenly discover that if we were short of air control we didn't have anything?

General METZGER. That is correct.

Senator MALONE. We had to control the air in order to control an area.

General METZGER. That is correct.

Senator MALONE. Then I am sure that Senator Murray will join me in this thought: That what the committee is trying to find out, not only what you will do if you just go along with our preparation as we are at this time without a war, but we have to be ready for the production of any necessary metal in the amounts that would be required if suddenly the war came that you have been talking about, because if we weren't prepared there—I will ask you this question:

To go into this larger production, what good would all of our other production do?

General METZGER. That is true, Senator Malone. I have gone through two of these defense buildups, World War II and the Korean buildup, and in both instances we have found it necessary, the Govern-

ment has found it necessary, to undertake priority controls and allocation programs of those now common materials, aluminum, copper, and steel, in order to accomplish those buildups. They have been in short supply.

Now, if we are to undertake another buildup, which I think we all agree would be necessary in the event of war, material such as titanium we are talking about today would undoubtedly be in short supply, and it is so short that allocation measures, priority measures, would be of little avail. I feel, from the testimony which has been given yesterday and so far today, that the present availability is so insignificant with the projected requirement that we had better not consider that through priority distribution programs that we will be able to accomplish the production goal, because we won't.

I also feel that it is reasonable to believe, in the event of an all-out mobilization effort, that the capability of the aircraft industry today will be utilized 100 percent. So when we talk about program levels, a billion pounds annual production of airframe weight which we did reach in 1944 in World War II, we can go one step further in employing and projecting the capability of the aircraft industry. We will utilize it. And the capability of the industry, as we know it today, must be satisfied in terms of all materials; and the most excellent work, Senator Malone, upon which your committee is engaged, in providing of critical materials for the defense of the country in the event of war—all materials—is certainly a vital program and one of the most worthwhile programs that I have ever witnessed.

I am doing a little talking here, but I feel very strongly on this point: That the material such as titanium or any material which is critical or in demand, in support of the aircraft program, must be available in sufficient quantities to satisfy the capability of the aircraft industry to produce in time of war.

Senator MALONE. Well, General, haven't we always found, especially World War II and World War I, that the plane companies meet every requirement in the production of planes that you could furnish them sufficient material to meet, within a very reasonable time; told them what they had to do; you gave them the material; they met it just as fast as it could be built?

General METZGER. They always did. There are always deterrents in the program objective brought about by labor buildups, training of skills, and the acquisition of plant areas and floor space, and the various engineering problems which they encounter in building new products, superior products. But the aircraft industry most certainly kept pace and paced their schedules to conform with the availability of materials and these other objectives.

Senator MALONE. There was no lack of initiative. I mentioned the Boeing and Douglas and Lockheed and North American and others.

But it seems to me we run in cycles. I have seen all three of these wars, as you have. I remember in 1917 and 1918 they were cutting spruce to make planes.

Mr. HITCHCOCK. It is all based on the billion pounds of airframe weight.

Senator MALONE. Based on something coming about that we see every day in the newspapers that we anticipate, is that right?

Mr. HITCHCOCK. Yes.

Senator MALONE. If we are building for a war, we want to balance our economy against what we can do. But, in the last analysis, in a fight there is no second-best airplane. It is eliminated. And these boys we are training cost a lot of money to train, and there are very few of them, and we want to preserve their lives.

So if we are talking business, which if I didn't think we were, I wouldn't be here—I am not interested in it at all unless we are serious in it—then I understand from your testimony, where you broke the ice in Henderson and said that there might be needed 100,000 to 150,000 tons of this material within a reasonable time in case of emergency, now we have absolute testimony, based upon the presumption that we get in a war—and if we are not preparing for a war we better forget it all. If we are, do it right. Then here is a corroboration of what you have already said, and that is, there is no other metal that will take its place at the speeds you are describing.

Mr. HITCHCOCK. Without a sacrifice in performance.

Senator MALONE. When you sacrifice the performance, you sacrifice the boy's life, don't you?

Mr. HITCHCOCK. Yes.

Senator MALONE. That is something we can't afford to do.

So for the benefit of the committee's study later, in which we will no doubt draft the general to help us analyze some of the testimony, and maybe some of your people later, we want to look into the future, and we can't look into the future. But the men who do the work making a real estimate, we know what estimates mean, but you are the only ones you can estimate; the general and Boeing and Lockheed and Douglas and North American.

General METZGER. Senator Malone, I have become greatly concerned here from the testimony which has been given, because if titanium is engineered into our military aircraft to the extent that it is evidenced is underway, planned presently——

Senator MALONE. Depending only upon adequate workable supply——

General METZGER. Then substitution at the time of production becomes nearly impossible if we are to meet our schedules. We just don't do it. I think Mr. Hitchcock will agree to that.

Mr. HITCHCOCK. Yes.

General METZGER. You can't rebuild an airplane overnight if you don't get the materials.

LIMITED MOBILIZATION

Senator MALONE. Therefore, it follows that you do not dare have your design adopted until you know that material will be available?

General METZGER. That is right. It is possible here, with the development proceeding as it is, at the pace it is, that titanium at this point becomes a limiting factor in a mobilization effort.

Senator MALONE. Now we are getting someplace.

General METZGER. If we tie our sights to the availability and lower our sights to the availability of titanium, our capability is nil.

Senator MALONE. Senator Murray, while you were out, I asked the general to comment on this possible demand testified to by the witness of 200,000 tons of sponge titanium in 1956, 400,000 tons or more in 1958 and 1959, in case of an allout war where we were required to go

into the airplane business just the same as World War II, and where they built a billion pounds of frameweight there, this is based on the assumption that we would go right back into the business to dominate the air; then the general called our attention to the fact that the witness is only talking about the frame, whereas with the engine and the other equipment on the plane, it would just about double it, which would mean 400,000 tons in 1956, assuming a war, and we were able to do it, 800,000 tons in 1958 and 1959. So I called attention to the fact that the general, at our first meeting—and I know you have had no opportunity to review the record as yet—testified that we might need, instead of the couple thousand or a little more tons that we are manufacturing now under those two 10-ton-per-day contracts, we might need 100,000, 150,000 tons a year. Everyone seemed a little surprised and shocked. But it now makes the general look conservative, and he wanted to be conservative.

So this, then, would be my only comment at this moment: That it is time we looked at the record; it is time we reviewed the record of the production of titanium, with only 2 companies in the business, with 3 or 4 more up at the gate pounding, trying to get in. Some think they have processes already that will top the Kroll process, and of course, that is what makes horse races. That is what makes us a great race of people. We always think we can beat the other fellow. If we didn't, we wouldn't be going very far.

Maybe it is time to review that whole record and see if we can't spread this out, because if this is true—and we are getting this information from the most capable people in the world—then there is plenty of room for more than two producers, potential. All the testimony from the beginning shows that under certain conditions it is indispensable. If it is only in commercial, you can keep your planes down and cost a little more and go along. But you can also make money, save the public money, by going into it.

I thought maybe you might have some comment. You missed that part of it.

Senator MURRAY. Well, of course, as you say, I haven't seen the general's testimony. I intend to review it. But it does seem to me the most important thing confronting us is the need of developing a supply of titanium. We are not going to be able to go ahead and design and go into the production of this new style of planes unless we know we have the titanium to carry out the program. That is what I would like to find out: How we are going to increase this supply of titanium.

Senator MALONE. Do you have further information for the committee?

Mr. HITCHCOCK. I think not, Senator Malone.

Senator MALONE. The final report of this committee won't be forthcoming for some considerable time, and if you have developed any ideas or thoughts on the subject in the meantime, you can supply us with them. You know what the problem is and what we are confronted with. If you think of anything that you could give us information on, we would be glad to have it.

Thank you, Mr. Hitchcock.

Do you have any further questions, General?

General METZGER. No.

Senator MALONE. Mr. Heath, of the Solar Aircraft.

STATEMENT OF W. C. HEATH, CHIEF ENGINEER, SOLAR AIRCRAFT CO., SAN DIEGO, CALIF.

Senator MALONE. Mr. Heath, you have been listening to the testimony. You know the objectives of the committee. If you will just identify yourself for the purpose of the record and take over.

Mr. HEATH. Thank you. I am W. C. Heath, chief engineer of Solar Aircraft Co. in San Diego.

Compared to the companies whose representatives have testified before in this committee, the part that our company has played has been very insignificant in the use of titanium. We are enthusiastic about the future of the metal in aircraft and believe its usage will increase by leaps and bounds.

My company, however, is basically a subcontractor and is therefore dependent entirely on our customers to say how much we build, how much titanium we use.

We have done a lot of development work, however, in titanium, mainly in the commercially pure. But we have done a little work on welding and cold forming of the alloys, and find that we may be on the road to finding a means of welding satisfactorily even the alloy, existing alloy materials. That is a long ways from being developed at this stage. The present welded joints on any of the titanium alloys are extremely brittle; vary from 0 to 1 percent elongation, which is not satisfactory from any structural point.

We believe that titanium is an excellent material for structural applications between 250 degrees to 800 degrees, which has been mentioned by almost all the witnesses who testified, and even higher in nonstructural application such as firewalls, where it has only to act as a flame barrier and not as a structural part. The reason it is good in that is because of its very high melting point, on the order of 3140 degrees Fahrenheit.

The most likely airframe applications that we see are as firewalls, shrouding around exhaust systems, skin and structure in the powerplant area, skin areas where the exhaust blast impinges, hydraulic lines, wing and fuselage skin and structure is high Mach number of military aircraft, hot air ducts.

I believe the use of titanium will show a far higher proportion of weight reduction in jet engines than in the airframes, since our analysis indicates that titanium could be used to advantage in shafts, engine frames, outer conbustion cases, compressor disks, and blades, bolts and nuts, tubing, vanes, and possibly even turbine disks, if they are properly cooled.

STAINLESS STEEL HONEYCOMB

One of my company's developments in high temperature, brazed stainless steel honeycomb, shows promise of supplanting titanium in some of these structural applications now contemplated in both airframe and engines. The surface in this field has barely been scratched. But the chief engineer of one of the largest of the airframe companies, after seeing a piece of this honeycomb stainless, told me he could visualize a complete wing of a high Mach number airplane being made in one piece using precipitation, hardening

steel such as 17–7 PH, where strengths up to 180,000 pounds per square inch can be obtained by heat treatment after the honeycomb has been formed and brazed.

Not only does this honeycomb have high strength, but it forms a smooth, fully supported, light skin and is rigid, so that much of the supporting structure can be eliminated, and it remains strong up to a temperature of approximately 1,700°.

It is possible, when brazing of titanium is developed to a higher degree and means are found of eliminating the brittleness of such joints, that brazed titanium honeycomb will further reduce weight in some of its applications in airframes and jet engines.

That, Senator, sounds like a sales pitch, and it was not intended for that. We think that this material will have quite an effect on the usage of titanium. It will supplant titanium, as I said, in wings and engine blades.

Senator MALONE. "The material will supplant titanium," what do you mean?

Mr. HEATH. This stainless steel honeycomb. I just happen to have a piece.

Senator MALONE. You are now showing us how to do without titanium?

Mr. HEATH. Yes, sir, in some applications. I don't think, by any means, this sort of material—and we are not the only ones working on it—will supplant entirely titanium. But it will supplant some of the titanium. In that way it will have some effect on your study of the titanium picture.

Senator MURRAY. If titanium is in very complete supply, it would be more favorable to use it than——

Mr. HEATH. In some cases, not in pipe. In many applications, I believe that a honeycomb material such as this will do a better job than plain titanium sheet.

Senator MALONE. About the same weight?

Mr. HEATH. Same weight or better weight or less weight.

Senator MURRAY. Would this have the strength of titanium?

Mr. HEATH. Yes, sir. If properly designed; it would have to be designed for its particular application.

Senator MALONE. It would also have the heat resistance?

Mr. HEATH. Yes, sir. It is good up to about 1,700°, which is way above that that you would use titanium for. This may well be a material that is beyond the scope of titanium in the higher temperatures.

Senator MALONE. Naturally, there are always competitive materials, and there are special efforts made, just as you are making here, for competitive material. We are very glad to have your testimony.

Now, in the matter of the plane sheathing or the plane skin or in any parts of the plane where the honeycomb material wouldn't be particularly applicable, then the stainless steel and the titanium would compete on the same basis it always has. But in points where you could use the honeycomb material, you think future study may show that it will be usable?

Mr. HEATH. Very definitely.

Senator MALONE. Very interesting.

Mr. HEATH. Because of the rigidity, a lot of the structure can be eliminated.

That is cold-formed, Senator. That is not hot-formed.

Senator MALONE. This titanium?

Mr. HEATH. Yes, sir.

Senator MALONE. What is this piece?

Mr. HEATH. That is what we call a bellows. It is used for expansion joints and hot-air ducts and things of that kind.

Senator MALONE. That is a weld in the titanium, which is an accomplishment in itself. It is hard to weld.

Mr. HEATH. The welding of pure titanium is not too difficult.

Senator MALONE. Is this pure titanium?

Mr. HEATH. Yes. This is the RC–70. It is the alloys that are very difficult. We have discovered a trick that leads us to think we may find a way of doing that satisfactorily.

Senator MALONE. In this use of the stainless steel bellows——

Mr. HEATH. This is honeycomb.

Senator MALONE. Honeycomb material of stainless steel; what part of this airplane construction that has been discussed might be taken by the honeycomb material that formerly we were talking about titanium?

Mr. HEATH. Wing skins for high Mach number airplanes, vanes, blades.

Senator MALONE. Frame?

Mr. HEATH. In engines. There would be less structural frame needed with a rigid material. So the airplane weight should go down because of the necessity for less structure, to hold the skin.

Senator MALONE. That is a very interesting development.

Do you have any further statement?

Mr. HEATH. I think that probably a higher proportion of weight in engines can be reduced, higher proportion than in airframes. We make a great number of stainless steel parts for most of the engine companies, and there are a great many parts that could be made, by our analysis—can be made of titanium that are now made of one or more grades of the stainless steels, and generally speaking they are the heavy parts of the engines.

Senator MALONE. In other words, even with this development, if it goes as far even as you think it will, there will be a greatly increased use of titanium also?

Mr. HEATH. Yes, sir. There is no question of that in my mind.

Senator MALONE. It just proves to me that, in all fields, when it is necessary and men devote their energy and time and brains to the job, they come up with something.

Mr. HEATH. That has always been true in this country, I believe, sir.

Senator MALONE. Do you have any questions?

Senator MURRAY. No, no questions.

Senator MALONE. That is all then, I think, and we appreciate very much your coming here.

Next we have Mr. Harvey of the Harvey Machine Co.

Will you come forward, Mr. Harvey?

STATEMENTS OF LEO M. HARVEY, PRESIDENT, AND G. A. MOUDRY, CHIEF METALLURGIST, HARVEY MACHINE CO., INC.

EXTENSION OF TITANIUM ALLOY

Senator MALONE. Mr. Harvey, you have long been in the machine-tool business and have a reputation of being very versatile in coming up with new ideas.

You have heard some of the testimony; you know the objectives of the committee. Will you identify yourself for the purpose of the record and give us any information that you think would be helpful?

Mr. HARVEY. I am Leo M. Harvey. This is G. A. Moudry, our metallurgist.

Senator MALONE. We are particularly interested, of course, in new methods in this titanium business. It has been said, and I think you told me yourself, that you had successfully extruded titanium-alloy shapes, worked with alloys. So just proceed in your own way.

Mr. HARVEY. I will show you a few samples of titanium. Here is a sample of titanium.

Senator MALONE. Is this extruded?

Mr. HARVEY. Yes. There is another sample, a long one, which gives you an idea what is being done.

Senator MURRAY. You extrude it just the same as aluminum?

Mr. HARVEY. Aluminum or steel, for that matter.

Senator MURRAY. This is pure titanium?

Mr. HARVEY. That is titanium alloy.

Mr. MOUDRY. Alloy.

Senator MALONE. Describe for the purpose of the record—there will be no drawing there—just what this is.

Mr. HARVEY. This is a piece——

Senator MALONE. Both of them.

Mr. HARVEY. This is extrusion of titanium alloy to be used for Lockheed Aircraft.

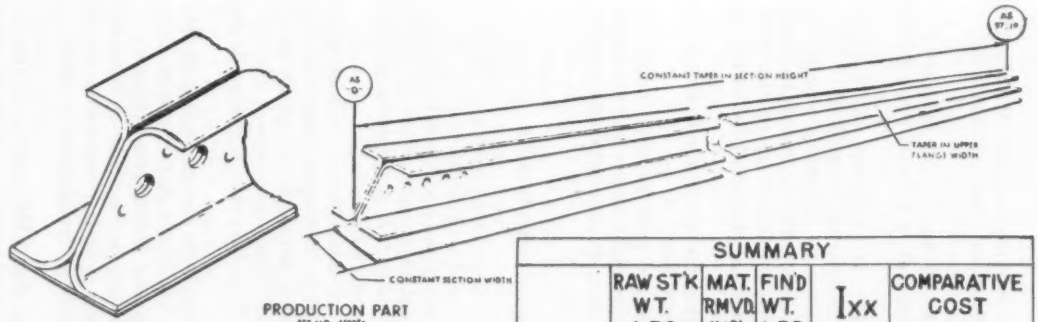
Mr. MOUDRY. Longeron.

Mr. HARVEY. Here is a drawing of it, [indicating] what it has been used for and the tensile strength and everything pertaining to it.

Senator MALONE. Make this part of the record as a part of your testimony. It is a chart showing the structure, extruded material; stainless steel, and you call it——

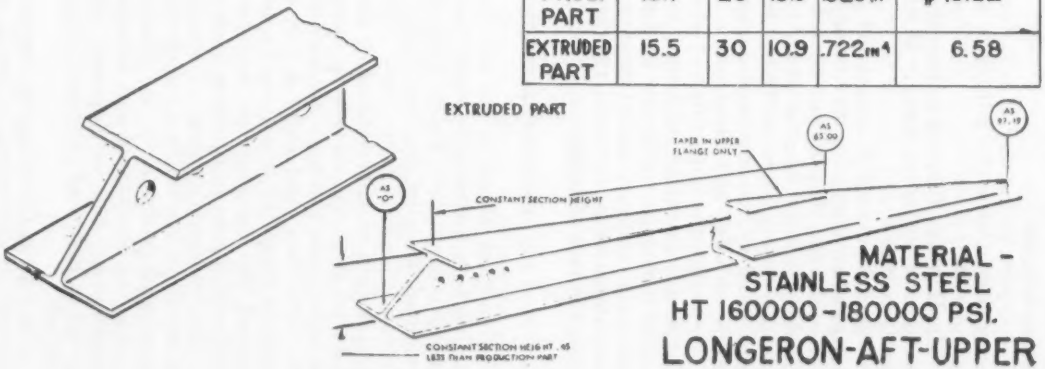
Mr. HARVEY. Longeron.

(The chart referred to follows:)



PRODUCTION PART
REF NO. 450086

SUMMARY					
	RAW STK WT. LBS.	MAT. RMVD. IN%	FIN'D WT. LBS.	I_{XX}	COMPARATIVE COST
PROD. PART	18.1	23	13.9	.326 in^4	$ 19.22
EXTRUDED PART	15.5	30	10.9	.722 in^4	6.58



EXTRUDED PART

MATERIAL -
STAINLESS STEEL
HT 160000 - 180000 PSI.

LONGERON-AFT-UPPER

Mr. MOUDRY. The upper part there is the way the part is actually made now on the ship, made by forming stainless steel sheet with doublers riveted together. By extruding a piece like this out of steel, the cost is one third. A weight saving is created, and a stronger part is made. Therefore by extruding the titanium, a further weight saving is made.

This part, by the way, is as it would go into a plane except for a few more rivet holes in it. I think it is the first one made successfully for an aircraft.

Mr. HARVEY. I have a statement I want to read to you that we prepared on what we are doing. It will give you an idea of what we are trying to do.

I have been actively associated with the development and fabrication of aluminum alloy structures for a number of years, and it seems almost heresy that at this time I am here to discuss a competitor metal. However, because we are in the center of the aircraft industry and serve every major airframe company, we are aware of the problems faced by the engineers engaged in designing and building the planes of today and tomorrow.

We realize the importance of having the strongest Air Force in the world, and the futility of having the second best.

Our technicians, who are in daily contact with aircraft engineers and their problems, realize the shortcomings of present known aluminum alloys when faced with the thermal barrier encountered by supersonic aircraft of today.

HEAT RESISTANT QUALITIES OF TITANIUM

Aluminum alloys as yet are the best structural material for the engineer on a strength-weight ratio but only at temperatures up to approximately 250° Fahrenheit. Our problem has been to develop an aluminum alloy which will perform satisfactorily at temperatures from 250° to 700° Fahrenheit. This we have not as yet accomplished and, in fact, we have nothing on the horizon to turn to.

Faced with the increasing demands of the aircraft industry for materials that will maintain high strength at increasing temperatures, we have been conducting a research and development program to provide competitive sections in steel and titanium alloys. The success of this development work resulted in increasing demands for extruded shapes in titanium alloys.

The measurable success of our company with the extrusion of titanium alloys is actually a tribute to the Air Force Air Materiel Command and, particularly, the Production and Resources Division.

It is the Production and Resources Division which instigated and implemented the development programs which culminated in the actual extrusion of titanium alloy shapes of configurations usable in aircraft.

The forward-looking top personnel in the AMC perceived the importance of keeping technology in advance of practice, and it is indeed gratifying to note that these men aggressively and successfully prosecuted their convictions to the point where major technological advancements have resulted.

Probably never before in the history of the development of a new metal has the technology advanced as rapidly as it has in the case of

titanium. The progress made in the direction of utilization of this new metal during the past 5 years has been spectacular.

It should be added that almost all the progress made is due directly to Government-sponsored and Government-directed programs. AMC has stayed in step with the whirlwind pace of titanium metal development, and at this point we wish to extend our appreciation of these facts before this group.

We have met with engineers of every major airframe company, at their request, to discuss the possibility of providing titanium alloy sections for planes as yet on drawing boards. We have been told that these planes of tomorrow must have titanium extrusions in order to withstand the temperatures and increased loadings now being faced as we pass the sonic barrier and approach the thermal barrier.

The aircraft industry has estimated that they may require approximately 250,000 tons yearly, finished weight, of titanium alloys for airframe structures alone for future aircraft. Of this amount we can expect that a minimum of 50,000 tons of finished extruded shapes will be needed. This requirement, of course, is predicated on the assumption that development will enhance the qualities of titanium alloys and reduce the price.

Since this survey was made, there has been an increasing interest in the use of titanium, particularly now that it has been learned that titanium extruded shapes can be made available.

In some instances, even at present-day prices, a titanium extrusion would pay for itself by increased performance over aluminum and decreased weight over steel.

Many sections are not designed of titanium because of the possibility that the metal would not be obtainable should a prototype plane reach a production level.

This has a parallel in the automobile industry wherein automobile engineers have been reluctant to design aluminum into their cars with the knowledge that in wartime emergencies aluminum is not available for civilian use.

Having watched the development of aluminum extrusions for the past decade and the development of aircraft over the span of many years, it seems almost a foregone conclusion that the impact of titanium on aircraft structures is bound to be far reaching.

In its few short years, development has been such as to revolutionize the thinking of our Air Force and aircraft engineers. It is known that the aircraft industry has arrived at the point at which the inadequacy of present structural materials is a critical factor, limiting performance of aircraft now in the design stages.

Titanium alloys will relieve this situation. Today we have alloys in titanium with ultimate strengths of 150,000 pounds per square inch. Some of the complex heat-treatable alloys developed by the Air Force indicate ultimate tensile strengths approaching 200,000 pounds per square inch.

As more experience is gained with the use of these alloys, they unquestionably will pay for themselves on a dollar basis and certainly will be a must from the standpoint of performance, both on a strength-weight and a temperature basis.

DOLLAR SAVINGS THROUGH USE OF TITANIUM

At least two aircraft companies have indicated to us that even at today's price for the metal they can show a saving on commercial ships where the dollar is all-important.

It is obvious, in military planes where our very life and security is at stake, that this metal and its alloys will be used in an ever-increasing volume.

At the request of the aircraft industry, following the success of our work in the extrusion of titanium alloys, we are taking steps to provide titanium sections for aircraft use. Along with this, we have promised the Ordnance people that we will cooperate with them in the obtainment of extruded sections. They have stated that they have a number of applications for the use of titanium in some of their structures. This is particularly true because the extrusion process provides metal where needed, and loss of material through machining is greatly minimized.

FUTURE OF TITANIUM

The following steps are being undertaken by our company at this time to further the titanium program:

(*a*) Expand our extrusion facilities to provide more capacity for the fabrication of titanium alloy.

(*b*) Arrange our forging facilities to produce forgings and pressings from extruded titanium stock.

(*c*) Work toward the ultimate goal of producing titanium metals. Our ultimate goal of producing titanium is aimed in the direction of using materials mined on the North American Continent, preferably the United States.

Investigations and studies conducted by us so far indicate the availability of such minerals on the North American Continent.

It is my belief that it is of the utmost importance, even to the point if necessary to make changes in the process of producing titanium, to use available domestic minerals.

It seems to me that the United States could not rely solely upon the importation from across any ocean of such a strategic material as minerals for producing titanium, particularly when the use of titanium becomes a must in the development of a first-class Air Force.

UTILIZATION OF TITANIUM SCRAP

It is our intention to provide melting facilities to alloy and produce our own ingot and absorb our own scrap. This will cut down the cost of the ultimate extrusion because we expect to produce extrusion ingot to size and thereby eliminate an intermediate operation. This should reduce the cost of the finished extrusion.

In our rolling mill which we anticipate will be installed in this area, we aim to make provisions for heavy-duty extra-powered rolls for future rolling of titanium alloy sheet and plate.

It has not been difficult to determine the desired requirements of titanium alloys for aircraft; we can determine what we should do to anticipate these requirements, but cannot predict the availability of titanium metal for our program.

I assume that this committee is searching for the answer to this question in this investigation, and I am confident that under the leader-

ship of able Senators Malone of Nevada and Murray of Montana an answer will be found.

Now, any questions you ask will be gladly answered.

Senator MALONE. Mr. Harvey, your approach is certainly new, at least to the committee, and very interesting.

Did I understand you to say that through your extrusion method, you are working on ways and means now to start with the sponge, utilize the scrap, and in practically one operation produce the usable material?

Mr. HARVEY. Not exactly that, Senator. What we expect to do is to use sponge and cast ingots the same as we are doing now with aluminum. We buy pig and make our own alloys. Then we can make the ingots more to size, eliminating a great deal of waste, which otherwise would result from forging material.

We are also working today with different institutions in the United States to produce a furnace which will be capable of using all scrap that we can produce and put it back in its natural form and keep it away from contamination. Now, that is only in the talking stage, but I believe it can be done, and we are working on it.

Senator MALONE. What value would this scrap have, after you have perfected its use, in relation to the material itself, that is, in the same relation as we speak of scrap iron in relation to steel?

Mr. HARVEY. Well, I would say the value would be nearly half of the cost of sponge.

Senator MALONE. Now, that would be really getting some place. If it remained at $5, then your raw material—when you use the scrap—would be cut in two.

Mr. HARVEY. Well, gentlemen, I think it is only in its infancy. I look forward to the time when the material will be sold for one-tenth of what it is selling for today. It is only a question of putting enough people in the business to create a condition of adequate competition under which prices may seek their normal proper level. I think you are the gentlemen to do it. There is no question in my mind as to the use of titanium, not alone for the defense requirements, but also for civilian requirements.

Senator MALONE. Give us an idea of the latitude of the civilian requirements in case the price got down somewhere reasonable?

Mr. HARVEY. Using it in planes as well as a lot of other applications.

Mr. MOUDRY. Corrosion is a factor in the chemical industry, valve industry, where today we have steel rusting and aluminum corroding. Titanium looks like it has a definite advantage if the price is down.

Senator MALONE. In chemical plants cost wouldn't be too important because of the replacements necessary for steel and other metals.

Mr. MOUDRY. Right.

Senator MALONE. Now, we have heard talk—we have not had any witnesses from the Navy Department, which we may before we get through—but because of its noncorrosive element, even under sea water, wouldn't there be expanded uses in naval requirements and other fields?

Mr. HARVEY. No question about it.

Senator MALONE. Hasn't it been the history of all metals that when they start to produce them for a certain purpose and then they become plentiful and the price goes down, the uses expand, just like aluminum and other metals?

PRICE HISTORY ON THE DEVELOPMENT OF NEW METALS

Mr. HARVEY. That is exactly what would happen. It happens to all metals, all alloys. As you know, aluminum was $50 a pound. I think it was more than that. It used to sell for $180 a pound at one time. And look where aluminum is now. We are finding more use for aluminum every day. No matter how much we make, it is still not enough.

Senator MALONE. In your experience with the titanium that has been furnished you, are the metallurgical properties and dimensional tolerances and other requirements satisfactory?

Mr. MOUDRY. We are fortunate in the extrusion operation primarily because we can take a billet, and if, for instance—we have problems of the segregation, the main problem, in sheet and bar and rod in the industry; in the very nature of the extrusion process, the flow of material comes from various areas of the billet, so if we have a segregated area in one spot, as it flows on through to form a shape like this, why, you blend it like you are pouring water from different pitchers. You are blending the material.

Senator MALONE. Like the shape shown in the diagram submitted in the record?

Mr. MOUDRY. Yes. This work was done under the General's division. He hasn't seen it. It hasn't been submitted by Lockheed as the prime contractor. That was produced under an Air Force contract.

Senator MALONE. Is it a report under one of the projects of Wright?

Mr. MOUDRY. Yes.

Senator MALONE. And will be submitted?

Mr. MOUDRY. Yes, the next week or two it will be in the hands of the people back in the field.

We find in extruding this shape—we have extruded up to 30 feet in length. We analyze the material from front to rear and keep on going through because the aircraft engineer isn't concerned about the properties here or there. They must be uniform throughout. We find very little difference in uniformity in the length of the section and across the area. Our average properties, let's say, in Rem-Cru's alloy 130B have been approximately 130,000 p. s. i. The top and the low have been very close to it.

Senator MALONE. "P. s. i." means pounds per square inch. I would like to have that in the record.

Mr. MOUDRY. Mallory-Sharon's alloy, that is, their 53 alloy which is supposedly the toughest one today; we have had very little difference in properties from the front to the rear of a section. We have had properties up as high as 170,000 p. s. i. When you are getting up there, you are getting up to where they are pretty strong. We are going to be doing work with alloys being developed by the Air Force with WADC, complex alloys. We will be working with Battelle and with WADC, which show properties up to 180,000 pounds per square inch. We can maintain those properties and gain in the extrusion process because we get a uniform section throughout as we extrude. So the testimony you have had, possibly in reference to sheet and pure properties, we won't have that so much to contend with in the extrusion operation, particularly if we start directly with a cast billet.

Senator MALONE. You are telling us, then, that when you take the sheet and press it or whatever you need to do with it, whatever defects remain in the same area, but in extrusion——

Mr. MOUDRY. They spread out.

Senator MALONE. Where the metal is extruded, it tends to be more uniform?

Mr. MOUDRY. Right.

Senator MALONE. Rearranges itself?

Mr. MOUDRY. We can't heal the major defect, but we can blend segregation in areas of that nature.

Senator MALONE. That is one of the advantages you think the extrusion method has over rolling or shaping?

Mr. MOUDRY. Right. In the work we have done, we worked with the three major producers of alloys, and in each case we worked with their worst alloy, toughest. In each case we had uniform properties throughout.

Senator MALONE. Now, I believe that extrusion method is a cheaper method of producing these shapes than any other method of rolling or——

Mr. HARVEY. Providing you need a certain shape. If you need sheets, extrusion wouldn't apply.

Senator MALONE. I am talking about working the shapes.

Mr. HARVEY. That is the cheapest method, by far the cheapest method.

Mr. MOUDRY. This section is actually being produced by us.

Senator MALONE. What do you call that?

Mr. MOUDRY. Flap track. It is produced in long lengths. We produce this only under one contract. This is one of the shapes to show it can be done. This is used today in a section like this. It is a production part. We will be extruding out of steel. At the present time it is being made out of bar and rod. The weight of the rod alone is roughly 24 pounds. The weight of the extrusion is less than 9 pounds, a saving of about 3 to 1.

Senator MALONE. Why?

Mr. MOUDRY. It is being machined today. Here are the chips that are lost. In dealing with a high-priced material like titanium, the extrusion process is of much more advantage, because the chips are valueless today, to speak about.

Senator MALONE. That is the scrap?

Mr. MOUDRY. The scrap. So you can make the best advantage of your material by extruding to a particular shape like in this one here. The end of this material, it wasn't changed one bit. That is a longeron. There are four of those that tie on the tail end of the T–33 plane. They have to use steel or titanium there. In fact, today stainless steel is being used because of heat.

Senator MALONE. Are there any of these charts or graphs that you would like to include?

Mr. MOUDRY. We will make these available. These are for talking purposes today. We will reproduce that one, and that one also. Another case we have here where extrusion is of advantage. Here is a case in steel. This is the way it is being made today out of a bar for a price of $29. This is the way it is being made today out of extrusion for a price of less than $9. This is also steel, can also be made of

titanium. The weight of the bar is 42½ pounds of material per foot. The weight of the extrusion is 5.7; 8 to 1. That is the advantage of the extrusion operation.

Senator MALONE. Do your same machinery and tools work on titanium that you now work on steel?

Mr. MOUDRY. Auxiliary equipment.

Mr. HARVEY. The extrusion press is the same.

Senator MURRAY. Very fascinating. Mr. Harvey has been very successful in his operations in the aluminum field, and I have great confidence in what he says.

Mr. HARVEY. I tell you; our policy is, instead of talking about it, we go ahead and make the piece and take an order and say so much for an order. "Do you want to take it?" It isn't experimental work.

Senator MURRAY. You intend to deliver the goods?

Mr. HARVEY. That is right; we do.

Senator MALONE. All you have to do is fit your specifications, I suppose. The general is the boss?

Mr. HARVEY. That is right.

Senator MALONE. Well, I can't say it is surprising; it is simply new.

Senator MURRAY. Wasn't there some talk in the hearings yesterday about the difficulties of extrusion? I thought I heard some testimony of that kind. Didn't you?

General METZGER. Yes.

Mr. HARVEY. Well, there is difficulty, of course. But if you want to do something that is worthwhile, you have difficulties. Otherwise, everybody would do it.

Mr. MOUDRY. We extruded titanium yesterday morning. It is too bad the committee couldn't have been over there.

Senator MALONE. Where is your factory?

Mr. MOUDRY. Right here in Los Angeles.

Senator MALONE. Sometime we will come and see it.

But we do not want to take too much credit for what we are doing. We are in a new field. It is the first time, at least that I know about, that the Senate has ever, through resolution, directed a committee to determine availability of materials for wartime and for expanded economy and for our security.

So it really has put us in two fields: First, to determine the best we can in the new materials such as titanium what field it will cover and the substitutions that it might make and its availability. It isn't of any use, no matter how good it is, if it is not available; and then to determine what areas of transportation lines can be kept open during a war, which may and could very probably, from information we have already received, exclude areas across oceans, because these planes that the boys will fly and the submarines are very likely to make it a very hazardous occupation, bringing anything across an ocean that weighs very much.

There are 77 of these materials, not all as important as this one, but they are all important when they pull the trigger on a war.

So what you are saying to us as to the development of the material and the new methods are not so surprising, because you always do it when it is necessary. It is a question of the Government going in like they did in the synthetic rubber and other ways and not going too far but going far enough to stand necessary losses in the process. I think that is exactly what the general has been doing with you.

Mr. HARVEY. Right.

Senator MURRAY. What I was interested in, to what extent can we find sources of supply in the United States and Canada so we won't have to depend on overseas for raw material?

RAW MATERIAL RESERVES UNITED STATES AND WESTERN HEMISPHERE

Mr. HARVEY. I believe there is enough raw material, that can be developed—they are doing it now—to produce titanium without going into other countries.

Senator MALONE. That is the answer.

Mr. Harvey, do you have anything further?

Mr. HARVEY. Well, all I want to say is this: You are doing a service, not only for defense, but also for the good of the Nation's civilian requirements. I look at civilian business just as a war would be; maybe it is a war of nerves, a different kind of war, but it is a war.

Senator MURRAY. The stronger we are in a civilian war, the more secure we are.

Mr. HARVEY. The stronger we are militarily. That is what we are doing. I believe we are only starting out. I can't imagine that the price of titanium will rest where it is now. With the help that you can extend to us, I think that titanium will come down to a great deal less than what it is today. It will be surprising. It will not take as many years as it took aluminum to be in the same place.

Senator MALONE. Perhaps, as has been mentioned here before, the war pressure will make more money available, and more brains available in the business, and shorten the time.

Mr. HARVEY. That is right.

Senator MALONE. The resolution also says, as you notice, "for the expanding economy," so we are interested in civilian uses.

All I would hope that our committee could do, Senator Murray—not all, perhaps, but one of the main things—is that when we are convinced, after reading the record and studying it, that certain things may be done, maybe we can break some bottlenecks.

Senator MURRAY. That is right.

Senator MALONE. Thank you very much.

We will adjourn until 2 o'clock.

(Thereupon at 12:45 p. m., a recess was taken until 2 p. m.)

AFTERNOON SESSION

(Whereupon the hearing was resumed at 2 p. m.)

Senator MALONE. The committee will be in order.

Mr. Pulliam, you are with the Kobe Iron Works of Japan, or Steel Co.?

STATEMENT OF KEELING PULLIAM, KOBE STEEL CO., JAPAN

Mr. PULLIAM. Kobe Steel Co.

Senator MALONE. Will you identify yourself for the record?

Mr. PULLIAM. Keeling Pulliam, Kobe Steel Co.

Senator MALONE. I understand that you are in the steel business but you are either in the business or will be in the production of titanium?

Mr. PULLIAM. Kobe has been very much interested in the production of titanium for some several years.

Senator MALONE. Do they produce titanium?

Mr. PULLIAM. Yes, sir, through their own sources and through subsidiary companies that they finance, sponge titanium.

Senator MALONE. You have listened to some of the evidence. You know the objectives of the committee. Naturally, we are interested in the supply of titanium, wherever it might come from, as long as it is in short supply. Will you then in your own way just give any information to the committee that you think might be helpful?

TITANIUM PRODUCTION IN JAPAN

Mr. PULLIAM. Well, Senator, the source of titanium in Japan is an iron sand, which readily produces titanium metal. The methods used in producing it have been very well cataloged. It seems to be very simple to use local gas and local electric current. The only element that has been in short supply has been magnesium metal for the final reduction of titanium into this metallic form. But through arrangements with Dow Chemical and with the Clark Patents, that situation will be remedied. In the meantime, the price of titanium has been a little high in Japan because of the shortage of the magnesium metal.

Senator MALONE. Production?

Mr. PULLIAM. Yes. Kobe has been known for some time as the Krupp of Asia. They are very well equipped with all kinds of fabricating equipment, very modern.

Senator MALONE. More than one plant?

Mr. PULLIAM. Several plants, but all under one ownership. They are interested, not only in producing titanium sponge for alloying in this country, but also in producing sheet bar stock, and they have been very successful in producing titanium welding rod and welds.

Senator MALONE. All their production is in Japan?

Mr. PULLIAM. That is right.

Senator MALONE. I think someone testified this morning just as an offhand statement that the best quality of titanium was coming from Japan.

Mr. PULLIAM. I am not fully aware of what that statement was because I wasn't here.

Senator MALONE. It was just a very simple statement, that it was good material.

Mr. PULLIAM. An industrial survey has been made of the industrial capacity of Japan. An associate of mine who is an industrial engineer was one of those who made this. And all the findings of that team have been made available to the Far East Air Force, and General Burnsides—whom I am sure you know—has made a report in full to Gen. "Troup" Miller regarding——

General METZGER. I have the report.

Mr. PULLIAM. It states in that definitely that Kobe has been able to produce satisfactory roll sheet, bar stock, bar and welding and welding rod. So that is a matter of record with the Air Force.

Senator MURRAY. Is this raw material?

UNLIMITED SUPPLY OF RAW MATERIALS

Mr. PULLIAM. Unlimited supply. Naturally, the economy of Japan hasn't been such that they wanted to undertake too much of either an outlay or development work until they were assured of some market for their product.

They are still in a situation of some uncertainty regarding their position with American markets. But I think it is a well-known fact that if the raw material is there that the cheap labor should be able to supply a finished product at a price less than could be produced in this country.

COST OF PRODUCTION OF TITANIUM

Senator MALONE. What do you pay for your skilled labor, in line with steel?

Mr. PULLIAM. About one-fourth.

Senator MALONE. One-fourth of what we pay here?

Mr. PULLIAM. Yes. We still have high-priced know-how. Some of it is foreign; some of it is Japanese.

Senator MURRAY. For the general labor though, it is pretty cheap?

Mr. PULLIAM. I would say you could get the kind of labor you would want there for, at the present rate of exchange, about a dollar and a half a day.

Senator MALONE. That would be 20 cents an hour about for an 8-hour day.

Mr. PULLIAM. Well, they work whatever is required.

Senator MALONE. Ten hours a day would be 15 cents an hour.

Mr. PULLIAM. I based that on an 8-hour day, Senator.

Senator MALONE. Twenty cents.

Mr. PULLIAM. We'll say from $1.60 to $1.75 a day.

Senator MALONE. As compared to $12, $15, to $20 here.

Mr. PULLIAM. The source of raw material is a commodity that Kobe controls; sufficient for many years.

Senator MURRAY. Where does this come from?

Mr. PULLIAM. Iron sand deposits.

Senator MURRAY. All over the island?

Mr. PULLIAM. Yes.

Senator MURRAY. Is it scattered, or is it in large——

Mr. PULLIAM. Large; steamshovel.

Senator MURRAY. I see.

Senator MALONE. Is it ilmenite?

Mr. PULLIAM. Ilmenite. According to the factory or pilot plant run sheets that I have seen and that have been submitted, apparently, the No. 4 process in American plants is the No. 2 in Japan.

Senator MALONE. Off the record.

(Discussion off the record.)

Senator MALONE. On the record.

Explain what is done.

Mr. PULLIAM. There are certain stages in the production of the metallic titanium, different reduction points. The No. 4 on the American method is equivalent to the No. 2 on the Japanese method, so that they reach the same point in progress with two less operations.

Senator MURRAY. We have to go four operations.

Mr. PULLIAM. No, there are more than that, but they reach a comparative production point in two less operations.

Senator MALONE. What does it cost there?

Mr. PULLIAM. I am not at liberty to say. This is somewhat exploratory for me. I appeared here on account of a statement that I read in yesterday's paper, where Mr. Lanphier, whom I know more than by name because his father and I served in France together in the First World War, stated the aircraft or airframe industry would be dependent upon the Government for their sources of titanium or their method of obtaining titanium.

I wanted, if possible, to obtain some information from the committee as to whether my search for information for Kobe in the form of statistics, as to alloys, gages and sizes of sheet, and other information which I am to supply them, should properly come from Government sources or from the airframe industry. Naturally, they wish to produce and submit for approval test titanium in a form that this country desires, and without that information it is a waste of time and effort on the part of all concerned.

Senator MALONE. What is the form in which they are shipping it to this country now?

Mr. PULLIAM. It is available in sponge, sheet, bar, or alloys.

Senator MALONE. Or in any forms?

Mr. PULLIAM. Any form you would wish.

Senator MURRAY. They sell us the sponge?

Mr. PULLIAM. That is right.

Senator MURRAY. We could do the fabricating?

Mr. PULLIAM. A certain amount of sponge would be absolutely necessary to be bought in this country because of the many different alloys which would be required here. So the flexibility of production would demand a sponge to a great extent.

Senator MALONE. What price are they selling it for here?

PRICE OF JAPANESE TITANIUM SPONGE

Mr. PULLIAM. That, sir, I would be happy to quote you if I was at liberty to. It would be considerably less than $5 that is offered on the American market today.

Senator MALONE. To whom are you selling it?

Mr. PULLIAM. We have been selling through Phillips Co. in New York at the present time, who represent the Sometomo Industry.

Senator MURRAY. That isn't Phillips Magnesia?

Mr. PULLIAM. No, Phillips, which is a trade organization; a trade trading company.

General METZGER. The entire output is committed to Phillips?

Mr. PULLIAM. That is right. But their production is very small.

Senator MALONE. About how much is their production?

PRESENT JAPANESE PRODUCTION

Mr. PULLIAM. About 1½ to 3 tons a month is all.

Senator MALONE. That is being sent mostly to the United States?

Mr. PULLIAM. The pilot plant is all that is producing. I have already in my hands the complete layout of the new plant which Kobe

will build. But, naturally, they are marking time until they can find out what they can expect in the way of a market.

Senator MALONE. All their supply is being sent, even though small, to the United States?

Mr. PULLIAM. That is right, everything coming out of Japan today.

Senator MALONE. How much do they think they could produce on a dependable basis, if the demand were here, on a contract?

Mr. PULLIAM. Fifty tons a month within 6 months, and rapidly from there on.

Senator MALONE. Any amount after that?

Mr. PULLIAM. That is right.

I wanted to present this information because I believed it would be of interest. I also wanted to find out from the committee, if possible, whether I was wasting my time talking to the air manufacturers in the aircraft industry as to what they wanted in the way of specifications.

U. S. REPRESENTATIVE OF KOBE

Senator MALONE. You haven't contracted with anyone now?

Mr. PULLIAM. No, sir.

Senator MALONE. For any more than what you are now?

Mr. PULLIAM. No. Kobe has contracted with no one. This is Sometomo entirely. The Japanese Metallurgical is the main source for Kobe.

Senator MALONE. Japanese Metallurgical is a company?

Mr. PULLIAM. Yes; a subsidiary of Kobe.

Senator MALONE. They do the actual production?

Mr. PULLIAM. The production of sponge will always be carried on by—we will call it a separate branch of Kobe or a subsidiary.

Senator MALONE. You represent——

Mr. PULLIAM. The parent company.

Senator MALONE. Here in Los Angeles?

Mr. PULLIAM. I live here in Westwood.

Senator MALONE. But you do represent them in the United States?

Mr. PULLIAM. That is right, for all of their production, wherever it goes.

Senator MALONE. Not only titanium, but other?

Mr. PULLIAM. Only titanium.

Senator MALONE. They must have an idea that it is a coming business.

Mr. PULLIAM. They intend to go into it in a very large scale as soon as they can see their way clear. They don't need any financing. They don't want any American loans.

Senator MALONE. What is the process they use?

Mr. PULLIAM. First, charcoal, then they break it down with—they form a titanium tetrachloride, and then they use oxygen and then vacuum, and in the final stage they use heat and metallic magnesium.

General METZGER. Kroll process.

Mr. PULLIAM. Yes. But the difference is in the base material, General.

Mr. ADLERMAN. Rutile?

Mr. PULLIAM. No; ilmenite.

QUALITY OF JAPANESE TITANIUM

Apparently, they can produce a very fine titanium. One thing I have been a stickler for, and which I went to the extent of finding out that they had instituted, was a very fine quality control, which we all know is very necessary on any product coming out of Japan.

General METZGER. That is right.

Senator MALONE. The Japanese have always been known as very fine precision workers.

Mr. PULLIAM. Yes, sir; but quality control on anything that was chemical was a little bit different than metallic. They can imitate some manufactured items so that its own producer wouldn't know the difference.

Senator MALONE. You heard the testimony this morning, which was not surprising to the chairman, but very welcome, and that is estimates of future use?

Mr. PULLIAM. Yes, sir.

Senator MALONE. Have you or your company studied the metal and its future application enough to comment on that testimony?

Mr. PULLIAM. Yes, sir; I can comment only to this extent: If Kobe didn't believe that it was one of the things that would supplant a good bit of their present manufacture, they wouldn't be so interested in going into it.

Senator MALONE. Their manufacture is in various grades of steel?

Mr. PULLIAM. Yes, sir; and fine milling work.

Senator MALONE. And chrome steel?

Mr. PULLIAM. Yes. They believe they have the source of raw materials, the source of the intermediary gas and electric power, and now have made magnesium available, sea water.

Senator MALONE. They manufacture the magnesium there?

Mr. PULLIAM. Yes; they are under licensing.

Senator MALONE. Plenty of sea water there.

Mr. PULLIAM. Yes. I heard a little bit of testimony this morning regarding the comparative cost of aluminum, which brought to mind that my father at one time gave my mother a pair of aluminum opera glasses, which he paid more for than a comparative pair in solid gold. I still have those glasses in my safety deposit box as a remembrance.

I am sure we can look forward to some great reduction in the price of titanium as soon as the companies are in production.

Senator MALONE. You speak about great price reduction. One reason the committee is interested—and we are not going to press you for any information that might be of value to your company alone—but you have heard testimony that beyond a certain point, even in warplanes—and of course certainly beyond a certain point in commercial planes—the cost was a factor. You also just told us your own story bout the production of aluminum and its history of price reduction where manufactured in volume and in general use and workability and all perfected. Do you think that same thing may happen in titanium?

Mr. PULLIAM. I don't think there is any question about it. I think the thing that is going to make titanium reasonable in price is the same thing that made aluminum reasonable in price: New manufacturing methods and competition.

Senator MALONE. That is the way we have lived here for 175 years, and we just want to keep it up.

Mr. PULLIAM. I am sure that it is the wish, for political and industrial reasons, to fortify the industry of Japan to take some of the load off of our taxpayers' backs, and I feel that this is one way that it can be done, because I think, from what I as an engineer have looked into, that Kobe is in a position to produce titanium in competition with anyone.

It is a reputable company of long standing with ample financing.

Senator MALONE. I was really surprised at the nominal fixed charges, even in Henderson, where we heard the first testimony. You heard me say this morning that 16 to 23 kilowatt-hours per pound was required, according to what processes were included in the statement. Different manufacturers have different ways of stating it. But it comes out about the same thing when you coordinate the statements. Let's say 20 kilowatt-hours per pound; even if you pay a cent a kilowatt-hour—and you can always generate power from steam if you have cheap fuel under that amount—it is not a big item when you are paying $5 per pound for sponge, and then there are other fixed charges.

Mr. PULLMAN. Senator, in Japan, we all know that the hydroelectrical power is available, plenty of gas, natural sources, so the only element I mentioned was magnesium, and that comes from sea water. So I can't anticipate but what you will have quite a reduction, particularly with the low labor costs.

ROLLING EQUIPMENT IN JAPAN

Senator MALONE. You heard someone say this morning that the rolling equipment was all the old-time steel equipment being used to roll titanium, and in their opinion it would be rolled better and faster and cheaper whenever there was enough of it to roll, so that investment justified going into special equipment; you heard that?

Mr. PULLIAM. Yes, sir. That is one of the reasons I mentioned that Kobe was known as the Krupp of Asia, and had modern rolling equipment. In fact, they have gotten some of it from Germany in the latter part of the war.

Senator MALONE. We see that Krupp is going into business again.

Mr. PULLIAM. The fact that I am trying to determine is, what can we do or what can I do to pass on to my employer, the company I represent, something that he can work on. That is why I have been going to the airframe manufacturers.

Senator MALONE. I don't know whether Senator Murray has any suggestions to make to you; the general might. They are both here. I would just simply suggest that you contact the people who are trying to contract for titanium. While we all have ideas as to how we ought to stabilize production in our separate countries, that is another subject entirely. The subject now is how to get titanium.

Mr. PULLIAM. The only reason I mentioned that was to indicate that a survey had been made, which had been put in writing, available to the Matériel Command, which substantiated the statements I am making.

MARKET FOR JAPANESE TITANIUM UNCERTAIN

Kobe stands ready and willing to produce titanium if they can have some sort of a long-time agreement, a couple of years or something, with even a clause in it for reexamination or revaluation on reduction of costs or anything of that kind; merely a letter of intent, if you want to put it that way, under which they can operate. They are not as aware of conditions probably as some of the people who live in this country.

Senator MURRAY. Wouldn't the very fact that we are conducting these hearings and considering the use of titanium on a large scale be sufficient indication to them that there would be a market, and naturally this country will have to trade with that country, with Japan, and I think it is perfectly natural——

Mr. PULLIAM. That is true.

Senator MURRAY. We would do some business with them, but we couldn't make any statement from this committee.

Mr. PULLIAM. I am not asking that.

Senator MURRAY. We are delighted to know that Japan has that source of supply, because I think it is very important.

Mr. PULLIAM. I hope they don't feel that it is the wish of the committee to develop solely American sources. That is the only point I am trying to get.

Senator MURRAY. I think we will have a tough time developing any great amount of it. Do you think so?

Senator MALONE. In a little while, anyhow. Anyway, that is a separate subject. Right now we have the general here wasting his valuable time unless we do advance some ideas in the committee.

Senator MURRAY. Even if we did develop them, Japan would have quite an advantage of being able to produce it cheaper than we do, and trade.

Mr. PULLIAM. It is an element of competition which might reduce the prices in this country, or at least be an incentive to the development of new methods in production.

Senator MALONE. Let me ask you: What is the attitude of the British Commonwealth in their trading area, in their empire preferential rates, in the trade from Japan?

Mr. PULLIAM. That, sir, I couldn't answer. The sterling block, in other words——

Senator MALONE. It might help you if you looked that up.

Mr. PULLIAM. I am interested solely in trying to interest the airframe manufacturers or other users of titanium in telling me what they want, so that Kobe can send the necessary samples or make the necessary contacts which would permit them to do business.

Senator MALONE. I am mentioning that simply because in England they now have quite a manufacturing program in planes, which might be increased, according to the press dispatches.

General, would you have any idea what they have in mind over there?

General METZGER. Well, no. I don't know the impact of the English program on just how large a production problem they have financed, production of aircraft. I do know that they are interested in titanium applications.

Senator MALONE. And they are manufacturing some titanium in England?

General METZGER. Yes, sir; very little manufacturing, I believe, Senator, at this time. They are about to engage in titanium production, but it is in a preliminary state today, as far as I know.

Senator MALONE. It seems to me you have several advantages. One is, your raw material is readily available, and here we are getting it from Australia, and in conversation with producers or potential producers, they are not finding it easy to secure the material. It is about the fourth most plentiful mineral in the earth's surface, they say. You have to concentrate it until it is profitable to mine; maybe it is in Canada, maybe the United States. There seems to be plenty of the material in this hemisphere, readily available. You, of course, have your sea water just as we do here, and manufacture your magnesium. Probably your chief advantage is your low cost, efficient labor.

There is quite a study going on now as to how America can hold its standard of living if Mr. Ford is going to hire $3 labor over in England and bring back a $700 Ford, which he says he can do—and I guess he can—whether the $15- or $20-a-day labor here should have any protection as against 15 cents an hour in Japan or $3 a day in England or $2.50 in Scotland or wherever it is, that is a question that is bigger than our question here today about the supply of titanium.

So I would say that anything you furnish in the next 2 or 3 or 4 years, probably you would be pretty safe. Then it would be a question of that difference in labor costs as to what the workers in this Nation thought about it, and many other factors. It wouldn't be any use fooling you about that. You know what this business is.

Mr. PULLIAM. Things change in 4 or 5 years.

Senator MALONE. It would be only fair to say to you that I have always favored the protection of American labor and small business as between the wage, standard of living, here and abroad, and we have been doing it for a hundred years.

Mr. PULLIAM. We all agree on that. We all agree, I think, that it is necessary that this country develop within itself sources of strategic materials that we need in wartime. However, if we have a present need that cannot be supplied, then let's look where we can get it.

Senator MURRAY. Then the present administration favors this reciprocal trade.

Senator MALONE. I am afraid they do.

Mr. PULLIAM. Also, Senator, I do think we have an interest in bolstering the economy of Japan.

Senator MALONE. Of course we do.

Senator MURRAY. Yes.

Mr. PULLIAM. Which is very necessary for all of us taxpayers. That is all I have to say. I intend to contact the airframe manufacturers and also the Materiel Command to obtain for Kobe the information they wish in order that they can start out with the program they have in mind.

Senator MALONE. The general right here would have as much information as any human being on the demand for what you are doing.

Mr. PULLIAM. I would like to have a chance to sit down with the general sometime.

General METZGER. I will be glad to talk with you about it. I am familiar with the problem. I can see no reason why you cannot dispose of all the sponge production you are capable of to the processors in this country. In fact, I understand that all of the Japanese production has very recently been contracted for by one of the metal producers in this country.

Mr. PULLIAM. Yes, sir, that it true, Senator.

General METZGER. That is right. It has been testified throughout this hearing and other hearings that this committee has held that there is at this point a very serious shortage of sponge, and that many of the metal producers, fabricators of titanium, are in the market for sponge. I see no reason why you are in difficulty in securing a market.

Mr. PULLIAM. I am also trying to obtain information, General, as to whether there is a market in this country for fabricated titanium in sheet, bar or stock, of various alloys.

General METZGER. That is a question of the ability of Kobe to produce alloys to the general characteristic specification required by the aircraft industry, the entire industry. I think you are aware that the problem of producing alloys is generally one of the manufacturer of titanium; the characteristics, the strengths that are required in specific aircraft applications are the specifications generally furnished the manufacturer, producer of titanium. He makes his own alloy to fit——

Mr. PULLIAM. The stress requirements.

General METZGER. Stress requirements and tensile strengths required. So I would certainly feel that your first step would be to sell sponge in this country and work into the alloy field and produce shapes and mill products in Japan as you are able to develop alloys which are competitive and attractive to the aircraft industry or to whatever segment of industry you wish to contact in this country.

Mr. PULLIAM. We feel that the nearer the completed item reached, the more we can benefit by the savings in cost of production in Japan.

General METZGER. That is very generally true, I think. But as I understand it from the delivered price of Japanese sponge, the possibility of lower-cost production in Japan is not being passed onto this country.

Mr. PULLIAM. A great deal of that, I am sure, is due to the uncertainty as to the volume that can be expected by the producers.

Senator MALONE. I think you have the information you can get from the committee because, after all, we are only two members of the subcommittee, and we have not built all our record; we have not studied it; have come to no conclusions, but at least have some idea of the demand.

Mr. PULLIAM. Thank you very much.

Senator MALONE. Mr. Shackman is here from the Rutile Production in Australia. Mr. Shackman.

STATEMENT OF ALEXANDER SHACKMAN, DIRECTOR, NORTH COAST BEACH MINERALS, SYDNEY, AUSTRALIA

Senator MALONE. Mr. Shackman, you have heard some of the testimony today.

Mr. SHACKMAN. Yes, I have heard a bit of it.

Senator MALONE. We are very glad to have you with us. I was in Australia a short time during World War II. People out in that mountainous country look a good deal like the people in Nevada and Montana.

Senator MURRAY. That's right, same stock, Irish and Scotch.

Mr. SHACKMAN. An English cross section you will find.

Senator MALONE. Very friendly people. I remember Australians in the First World War in France. Americans and Australians always got along fine.

RUTILE PRODUCTION IN AUSTRALIA

So if you will identify yourself for the record, and make any statement that you care to that you think would be helpful to the committee.

Mr. SHACKMAN. I am a director of North Coast Beach Minerals, with offices in Sydney, Australia. We are primarily engaged in the production and recovery of rutile. The board is no doubt familiar with the way rutile or any of these beach minerals are gathered.

We are a new company there. At the moment there are approximately eight existing companies in Australia. Market price in relation to selling price has in the last year been declining, due to a limited demand for this particular material in the United States. It is very relative to quite a number of factors; the slow time lag in the production of a titanium sponge, to do it successfully and to do it on a mass production basis; secondly, the welding rod industry. Due to the fact that war in Korea has now become nonexistent, a cutback in production orders by the United States has reduced the requirements for rutile in the welding rod industry.

What we are mainly interested in in Australia at the moment is: Will our rutile be required in the production of titanium sponge in the United States? Will it be given possibly an advantage as far as the United States companies are concerned in the production of titanium sponge?

We know at the moment that titanium slag is very much in the minds of most American producers because it is indigenous to the United States, the Northern and Southern Hemisphere.

What we would like to know is: Is the United States prepared to take the present production of rutile available in Australia during the years where shipment is possible, preceding any war effort, whether the sea lanes are open or not.

We realize that this mineral is not a lightweight material that can be flown in. We would prefer to see it produced in the United States because they have the ingenuity for it. Australia is not a wealthy country in relation to capital wealth. She is not productive enough. Her labor capacity is limited, inasmuch as she has a population of 9 million at the moment, which is growing. She is approximately 12,000 miles from Great Britain, where most of the production effort is centered for the British Empire.

I am purely and simply appearing here before Mr. Malone and the committee to find out how we can be helpful should the United States Government or the United States manufacturers desire our rutile; also, to anticipate increased production methods over there in relation to an increased demand.

Senator MALONE. I think you put your finger right on the vital nerve. You were probably here when I explained the responsibility of the committee in determining the availability of these critical materials to the United States in wartime, and its increased economy, and for its security. Many believe—and I think from your conversation perhaps you have an idea—that if the third or fourth, whatever they call it, allout war started, perhaps it would be very difficult to ship heavy material and shiploads on the water surface from any country across a major ocean. Many of our people believe that. Therefore, as long as we are threatened with a war, we build ourselves up to the point where we are apparently expecting a war or, at least, have to be in a position so that our potential enemies do not think there is any use to attack us if we are to prevent a war. We are on a war economy.

The job of the committee is not to interfere with trade, normal trade, but to determine availability of these supplies in wartime. There might be a little difficulty if we were to develop domestic sources for wartime. You are familiar with mining operations if you are in the rutile business. Any company that develops a deposit of anything has to sell it as it goes along, so if you have a going concern in the mining industry, ilmenite or rutile, in this country, it might be a little difficult to hold it in abeyance for a war. I can see your point exactly, and that is the reason I am glad to hear from you.

You say there are 7 or 8 companies there interested?

Mr. SHACKMAN. Operating at the moment. Two American companies at the moment.

AMERICAN INTERESTS IN AUSTRALIAN RUTILE

Senator MALONE. Who are the American companies?

Mr. SHACKMAN. Titanium Alloys, a division of National Lead Co.; there is also Metal Recoveries Propriety, Ltd., Ventures, Ltd.

Senator MALONE. British?

Mr. SHACKMAN. Canadian, with intense American connections.

Senator MALONE. Probably controlled in America?

Mr. SHACKMAN. I wouldn't say that. I do not know their corporate structure. I would say that they are controlled worldwide by English and American interests, primarily, in relation to the fact that their company is tied up with the United States.

You state or you are trying to propose here a required production of approximately 200,000 tons of titanium sponge by a specific period.

Senator MALONE. Annually.

Mr. SHACKMAN. Which would be your requirements.

Well, on the present breakup of utilizing rutile, that would take about 2½ to 1 on the raw mineral; that would bring the need for rutile, whether it is rutile or titanium slag—titanium slag is about 3½ to 1 breakup—it would bring it in the vicinity of 700,000 tons of rutile. Australia at the moment could not produce that type of production.

Senator MALONE. All eight companies?

Mr. SHACKMAN. All eight companies. Last year, if I have the figures correct, there were 38,000 tons of rutile produced in Australia. The United States produced a comparable 10,000 tons; not actually

rutile; it is leucoxene, which is produced by the du Pont Corp. in Florida. That, as you can see, is only a minute fraction of your requirements. It would take Australia at their present production rate 20 to 25 years to give you your requirements unless they expanded their facilities.

If the United States at the moment were considering expanding their titanium sponge production, they know, and we know, that at the moment the rutile is a successful product in the production of this particular metal, and we think that titanium slag will also be successful. As yet it has not proven successful in the mass production stage. Should the United States be considering starting several new plants so they can get into a production stage in the event of war, they would need titanium slag in the experimental stage, possible production stage, or rutile, which could go right into production.

The present market of rutile, as I said, was fairly low. It is forcing some of the producers to sit back and possibly be absorbed by larger companies, if the companies wish to take that risk, or go out of business, which in effect would reduce the amount of rutile which can be supplied to the United States by other world markets.

We are not interested in begging or pleading with the United States to buy our production. We would like to see them do it on some equitable basis. If they want to set a price fixed on a particular material and wish to stockpile it as a strategic metal, I know they have taken it off the strategic-metals list, but if they desire to stockpile it, I am quite certain that the Australian Government and the Australian manufacturers could get together on the fixed price over a period of time, possibly 5, 10, 15 years.

It would mean this: That in the interim period, in view of the fact that there is a lag in the production with relation to titanium slag, it would mean that the United States, by putting this material back on the strategic basis, could stockpile it again, and would then come into the buying market. At the moment she is no longer in the market for rutile. As you know, the principal source at the moment is Australia. Our estimated reserves there are pretty difficult to comprehend. The funds of the Australian mineral departments are fairly limited. They cannot go out and develop or bore areas to find what the reserves are. They depend upon the specific manufacturer to go out and prove his own reserves. Well, each manufacturer does that, but he only proves what he is going to use in the next 2 or 3 years. He knows that there is sufficient available.

So probably the present figures which may be available as to the amount of reserves Australia covers is probably about one-one hundredth of what actually is there.

If Australia, as a rutile producing nation, could be of any use to the United States at the moment in the production of rutile, we would be prepared to enter into some sort of an agreement. The agreement naturally is one-sided. It is dependent upon the United States.

Senator MALONE. I think that is a very fair statement of your position, and I can understand your position.

Do you have any questions?

Senator MURRAY. No.

Senator MALONE. General?

General METZGER. No.

Senator MURRAY. We are talking a lot in this country about international trade and free enterprise and reciprocal trade. It seems to me that Australia, being a friendly nation, belonging to the nations that are allied with the United States, ought to be able to get into the market here without any agreement even.

Mr. SHACKMAN. Well, there again, they are in the market; there is no question about that. Australia sells most of its rutile to the United States. It is not a matter of market. We are interested in whether the United States would be thinking about our mineral as a long-range development, or do they wish to just say they will buy what we offer and "Take your competitive market," which we are quite willing to do if the United States does not want anything else. We are not going to cry about it; continue the way we have been doing. We can sell our present production possibly at lower prices, because the market is a bit more competitive; we can sell to West Germany; we can sell to Great Britain. Possibly, Great Britain might have the idea of putting up their own plant in Australia. At the moment they have a small pilot plant in England, which will be capable of producing about 1,500 tons per year of titanium sponge. You are probably aware of that.

With the raw material lying in Australia, it might be more advantageous for England to produce in Australia. But if the United States is inclined to and wishes to buy the mineral, Australian manufacturers at the moment can increase their production if they are given any indication that there will be a market for their increased production.

Senator MALONE. Do the Germans have plans for production of titanium?

Mr. SHACKMAN. That is correct.

Senator MALONE. Are they producing any now?

Mr. SHACKMAN. A pilot plant is in erection stage at the moment. West Germany has been buying rutile. They bought fairly heavily about a year and a half ago, and they are contemplating titanium production. As you know, they are a manufacturing nation, and it seems foolish to think that they won't start their own plant there.

Senator MALONE. Do the Australian people have any information on the possible Russian production?

SHIPMENTS OF RUTILE TO EUROPEAN FREEPORTS

Mr. SHACKMAN. We do not have any whatsoever. We understand, purely and simply word of mouth, that some of this rutile which we are shipping out has been going into free ports. Well, it could be going anywhere.

Senator MALONE. Where are the free ports?

Mr. SHACKMAN. Specifically, I couldn't state as such, but I think some has gone into Trieste and possibly some other nations. You could probably get that from your Commerce Department.

Senator MALONE. Do you know where you are shipping materials outside the shipments to Germany?

Mr. SHACKMAN. Yes; we usually known where we are shipping.

Senator MALONE. Well, is it going into these so-called free ports?

Mr. SHACKMAN. Well, there was some that went in under license.

Mr. ADLERMAN. Trieste, Rotterdam?
Mr. SHACKMAN. Not that I know of.
Mr. ADLERMAN. Any to Rotterdam?
Mr. SHACKMAN. There may have been some.
Mr. ADLERMAN. Hamburg?
Mr. SHACKMAN. Hamburg; yes.
Mr. ADLERMAN. Bayreuth?
Mr. SHACKMAN. No.
Mr. ADLERMAN. Hong Kong?
Mr. SHACKMAN. No; the Eastern market hasn't worried very much about rutile.
Mr. ADLERMAN. Have you had any going into the Scandinavian countries?
Mr. SHACKMAN. I am not familiar with that. I wouldn't wish to make any statement relative to that. All shipments out of Australia are licensed out of Australia. They are licensed to British ports. They may be reconsigned. We do not know that.
Mr. ADLERMAN. All the ones that go to free ports are licensed?
Mr. SHACKMAN. Oh, yes, they are definitely licensed. There has been no trading whatsoever, direct trading, with any Iron Curtain countries.
Senator MALONE. That is, Australia has not had?
Mr. SHACKMAN. That is correct.
Mr. ADLERMAN. Any destined to Switzerland, that you know of?
Mr. SHACKMAN. No; not at all.
Senator MALONE. As long as we are in the trading field, are you familiar with the trade agreements that were made during the war years, following the war years, that are in existence at the present time between the European nations and the Iron Curtain countries, Russia?
Mr. SHACKMAN. No; I am not familiar.
Senator MALONE. At one time, and I don't intend to go into it here—it is a different subject—I put 96 different trade treaties in the record, made by 17 Marshall plan countries with Iron Curtain countries and Russia, showing exactly what they shipped to Russia and what they received, which ranged from ball bearings to engines, and it was quite a problem and probably still is.
Still, that doesn't keep your problem from being acute and from being handled if the country involved wanted to do it.
What arrangements do you have generally with the British Empire and England in the matter of shipments of goods into England, or what you can do if you wanted to produce, we will say, titanium in Australia in competition with England, Australian-American or Australian capital?
Mr. SHACKMAN. Australia deals on an open market, a free market. She is free to deal with the United States at any time.
Senator MALONE. She is free either to buy from any nation in the world without any restrictions or to sell to any nation?
Mr. SHACKMAN. She is free to sell to any nation of the world. She is free to buy from any nation if she has that currency to buy with. The American dollar goes into a sterling pool in the British Commonwealth.

Senator MALONE. Explain that. Will you give us an idea how that works?

Mr. SHACKMAN. I am not a financial expert.

Senator MALONE. I know that. Neither are most of us.

Mr. SHACKMAN. Simply a layman's attitude.

Senator MALONE. Tell the committee about it.

Mr. ADLERMAN. Trace through a transaction if you sold to the United States.

Mr. SHACKMAN. If you sell rutile to the United States at the moment, you would receive a letter of credit from a United States bank in dollar currency. That would be deposited, to be drawn against your account from an Australian bank. Now, you would receive payment in pounds, Australian pounds. The dollar credit, if there is a favorable allocation to Australia, would remain in Australia, because Australia works on an allocation from the British sterling pool. If the allocation was unfavorable, it would return to Great Britain, and they could therefore buy dollar commodities with the dollars which were earned by the Australian Government.

That is an internal problem in the British Empire. That is their own problem.

Now, regarding reciprocal trading, reciprocity is not allowed, whereby you can ship rutile to the United States and take machinery back, in effect. You cannot do that. It still operates through a dollar pool. You cannot establish reciprocal trade agreements. Actually, what is occurring, all of the nations of the British Commonwealth are contributing to the strengthening of the economy of the British Empire.

Senator MURRAY. British Commonwealth.

Mr. SHACKMAN. The Commonwealth of the Empire. Primarily, as you know, England is the manufacturing portion of the Empire.

Senator MALONE. Why?

Mr. SHACKMAN. Well, at the moment they have the ingenuity for it. They have the material. They have the men. That is going back into British history, I think. It is a political point.

I am an American myself. So it is pretty difficult for me to understand it at times, too, why.

Senator MALONE. Were you born in America?

Mr. SHACKMAN. Yes; I was born in America.

Senator MALONE. You have an accent. I was under the impression you were from Australia. I still say that Australians are more like Americans any place you meet them in the world than any other people.

Mr. SHACKMAN. I lived there for quite a number of years. I first arrived out there in 1941 with an American organization, and I have been back and forth in the past 12 years. I have lived there continuously for the last 5 years.

Senator MALONE. What in general is the range of wages in this industry paid there?

Mr. SHACKMAN. The range will follow a basic pattern. There is a basic wage there, which is determined by a commodity range or a statistical range in relation to the economy of the country. If the price of food goes up, wages go up.

Senator MALONE. Where do you start? What is the base wage, semiskilled and skilled, we will say?

Mr. SHACKMAN. The basic wage does not take into consideration skilled or semiskilled.

Senator MALONE. Is it all one wage?

Mr. SHACKMAN. The labor unions, or the unions, bargain for each skill, and they determine that.

Senator MALONE. But what is it at the present time, common labor?

Mr. SHACKMAN. The basic wage at the moment varies in each State, but I would say it would be about 11½ to 12 pounds.

Senator MALONE. 11½ pounds per what?

Mr. SHACKMAN. Per week, per 40-hour week.

Senator MALONE. How many dollars to the pound?

Mr. SHACKMAN. $2.24 to the Australian pound.

Senator MALONE. That is the Australian pound?

Mr. SHACKMAN. That is correct.

Senator MALONE. Why is it different from the British pound?

Mr. SHACKMAN. Well, there again, another agreement, and that is dependent upon Australia. Australia can come up to parity to the English pound if she so desires, but there again it is a country that wishes to stay 25 cents below the British pound.

Senator MALONE. That is approximately $25 a week?

Mr. SHACKMAN. A bit over $25 a week. Now, our average wage, inasmuch as we employ skilled labor, is approximately 16 to 17 pounds per week. That follows the average wage of all wage earners in Australia, which runs in about that category.

Senator MALONE. About $35 per week?

Mr. SHACKMAN. About $35 a week. That is the average wage. That is not the basic wage. That is purely and simply used as a yardstick.

Senator MURRAY. Do skilled workers get very much higher wage?

Mr. SHACKMAN. Skilled workers get much more money. They compare relatively to the United States.

Senator MALONE. What would a skilled wage earner get there per week?

EARNINGS OF SKILLED LABOR IN AUSTRALIA

Mr. SHACKMAN. Well, as I said, about £17 to £18 a week, about $35 to $40 a week.

Senator MALONE. Skilled labor here is way above that amount.

Mr. SHACKMAN. Yes, I am well aware of that. Now, in 1941 the basic wage was about £4 5s. The pound at that time was worth about $3.33. That was the equivalent of about $14 a week. Now, skilled labor at that time was probably getting about £7 to £7½ a week.

Senator MALONE. You see, we also have a basic economic problem here, which would be resolved on the Senate and House floor. There is no use going into it now except to this extent.

I am very much interested in your problem, speaking for one member of the committee, and I can see that Senator Murray is also. But we also have a problem, and that is the wage standard of living difference when you go into competition.

Mr. SHACKMAN. We are not asking to compete with the United States. We are purely and simply selling a raw material.

Senator MALONE. Isn't it the same in zinc and lead; you are in competition whether you like it or not?

Mr. SHACKMAN. No, we are——

Senator MALONE. Once you are producing it?

Mr. SHACKMAN. We are not in competition with the United States. If the United States has no need for our material, there is no need.

There is no use for the United States to buy that particular material if the material isn't of advantage to the United States. We are more than willing to supply it to the United States if we can be helpful to the United States and help them with their production program.

Senator MALONE. It is a nice way of putting it, but we are not facing our problem, and we will allow that to go. But the record will show your problem, of course, is to sell your material. Our problem is to have material that we can get in wartime and have it available in wartime, whether we produce it during peacetime or not.

Mr. SHACKMAN. That is correct.

Senator MALONE. There is no question but what you can produce it cheaper than we can with your labor and the cost of our labor, so that is our problem.

Mr. SHACKMAN. Just a moment. The material is not available here for production.

Senator MALONE. It is available in this hemisphere without any question in ilmenite.

Mr. SHACKMAN. Rutile.

Senator MALONE. We have gone all through that. Ilmenite will do the work, so that is our problem.

Mr. SHACKMAN. Well, I am well aware of that. I know that. Ilmenite has a TiO content similar to rutile. The percentages are different.

Now, if you could use ilmenite successfully at the moment in the production of titanium sponge, you would be using ilmenite at the moment for the production of that sponge. Australia has a raw material. If it is useful to the United States and available to the United States, if the United States wishes to buy it in quantities, wishes to increase the quantity that they purchase, the production of that particular material can be increased abroad.

Senator MALONE. I think that is a very fine attitude for you to take. We will let the record speak for itself. I think we all know it is available.

Now, let me ask you: Could you install titanium production in Australia if you so desired, and you financed your company and started production just like they are in England or Germany or here, and sell it any place you wanted to?

Mr. SHACKMAN. I do not think so—this is my personal attitude—in relation to a plant for the production of titanium sponge in Australia. It takes a considerable amount of money to build.

Senator MALONE. Skip that. I am asking you, if you had the money.

Mr. SHACKMAN. Certainly.

Senator MALONE. You have no one but yourselves to consult, if you thought the market was there for titanium in the world, and you could finance it, either here or in Australia or in Germany—we'll go back and build it there—there is nothing to keep you from building it and offereing it for sale?

Mr. SHACKMAN. That is correct.

Senator MALONE. I think you have made a good witness, and I am mightly glad you are here. If you think of any more information that you think would be helpful to the committee, don't hesitate to send it in.

Do you have any more questions?

Senator MURRAY. I have no questions.

Mr. SHACKMAN. Thank you very much, sir.

Senator MALONE. Thank you. We are glad to see you.

Mr. Holloway of the Crane Co.

STATEMENT OF J. L. HOLLOWAY, PRESIDENT, CRANE CO.

Senator MALONE. Mr. Holloway is connected with Crane Co., that has recently contracted to produce a certain amount of titanium.

Mr. Holloway, we are glad to see you here today. We know something about your basic company and have for a long time. We know nothing but good about it. It has been successful, as far as the chairman knows, at least, in all of its undertakings. We are glad to see you undertaking a tough job.

You have heard some of the testimony; you know in general the objectives of the committee. Would you identify yourself for the purpose of the record and give us any information you think might be helpful?

CRANE CO.'S PLANT CAPACITY

Mr. HOLLOWAY. I would be happy to. J. L. Holloway, president of Crane Co. Cramet, Inc., a wholly owned subsidiary, has contracted with the Government to produce 6,000 tons of titanium sponge per annum.

The plant has been located in Chattanooga. After a very thorough study, we found that in our opinion that location fitted best the commercial aspects of the entire project. The site preparation is well along and should be completed within a week. The first two buildings are well under construction. A very substantial part of the equipment for these two buildings is ready for delivery.

We contracted for the equipment 9 months ago, with the idea that if the Government contract didn't materialize, why, we were going to use at least that much in a company project.

So I fully believe that within 7 months this first stage will be in production. There won't be a great deal of sponge. It might run to a couple hundred ton a year. However, the main plant is well engineered by now and will be brought into production progressively, so that the production from it should start within 12 months. I am very hopeful that it will reach its capacity within 20 months.

The plant has been so laid out that it will be a very easy matter to add to the facilities so as to at least triple and probably quadruple its capacity.

We have been, of course, very conscious of the matter of cost. It is very important. We have three other methods developed by ourselves for producing titanium. But, in our opinion, the modified Kroll process, which is to be employed at this Chattanooga plant, was the only one whereby we could get quantity production within a matter of a few years.

Senator MALONE. You speak of a modified Kroll process. What do you mean by that?

Mr. HOLLOWAY. Well, we incorporate in our process some features not in the basic process developed by Dr. Kroll.

Senator MALONE. Features that you have developed in your own research?

Mr. HOLLOWAY. That is right. We have been researching titanium, in fact, producing it in a small plant for close to 3 years.

Senator MALONE. When a company such as yours ventures into an entirely new field, there is always a good reason for it. Of course, there is sometimes a patriotic reason, and that might be plenty of reason for it if a war were imminent or if we were now engaged in a war. But you are apparently voluntarily, at your own urging, your own company, going into this business.

What do you think of the future of the business? You have heard some of the testimony here. The committee is intensely interested, as you probably noticed, in finding out what the present use is, what it would be if workable material were available in quantities, so that the designers could just forget all about the supply as they may now in the matter of stainless steel and aluminum, and just turn loose, filling specifications laid down by the Air Corps, as represented by General Metzger here.

Sometimes a man just coming into a business with no inhibitions about being stymied for years on production and use, one thing and another, has some ideas of his own. What are your ideas about this metal?

USES FOR TITANIUM

Mr. HOLLOWAY. Well, I am very optimistic regarding its use. I might start though with the Air Force. Through other activities of our company, I am very well acquainted with the airframe builders, and I know there is a terrific economic need for titanium in the aircraft business.

But going on beyond that, its strength-weight ratio has a great economic appeal in other fields. Its corrosion-resistance certainly in the handling of sea water makes it very desirable; and last, but probably in the long run, far from least, its expansion coefficient, which is very low.

Senator MALONE. It has not been mentioned.

Mr. HOLLOWAY. Could make it, at a proper cost, a very vital building material.

Senator MALONE. What do you mean, "a building material"?

Mr. HOLLOWAY. Well, in place of steel. Now, I have heard, I thought, some rather optimistic ideas on the price of titanium this morning. When I start comparing it with the price of steel—it may be ridiculous today; I think it is today—but that doesn't say it can't come about. I don't remember the exact figures, but I think you will find that titanium under heat expands only about 15 percent the extent that steel expands, and expansion and contraction is a construction problem wherever you go.

Senator MALONE. That might be a very important factor. It has not been discussed before this committee.

Mr. HOLLOWAY. I think that is a long way in the future, as I have said. These other processes are not here today, and it is going to take some years to develop them.

The big factor that has just been touched upon since I have been present is the cost between the sponge and the sheet. So many folks keep talking about the cost of the sponge, at $5. Well, let's say we cut it to a dollar. But today your sponge costs $5 and sheet costs $20. You have $15 to work with.

Senator MALONE. That is the rolled and formed sheets?

Mr. HOLLOWAY. That is right. Of course, that includes reducing the sponge to ingot, but then rolling that ingot into sheet. So there is three times as many dollars to work with between the sponge and the finished sheet as there is in the sponge end of it.

Senator MALONE. That is a very interesting spread to an engineer in the business.

Mr. HOLLOWAY. I think that there is a lot to be learned in the rolling technique. Further, I am sure that the—let's call it instability of ingot produced to date has been a high cost in rolling.

Senator MALONE. The nonuniformity?

Mr. HOLLOWAY. That is right. One of our objectives is, first, to produce uniform ingot of whatever alloy or pure titanium, and then at present we have made arrangements to have it rolled in a specialty mill, a small mill accustomed, day after day, to rolling high-cost high-alloy materials. Eventually, I think that we should have our rolling mill.

Senator MALONE. Not try to do it in a steel rolling mill at all, but have a special rolling mill?

Mr. HOLLOWAY. That is my idea.

Senator MALONE. That would naturally come when the volume justifies it, I suppose?

Mr. HOLLOWAY. That is right.

Senator MALONE. What did you think of the testimony here this morning about extrusion methods of forming this metal?

Mr. HOLLOWAY. I think it is very appropriate, very interesting. Of course, it will not apply to many things. To the shapes it can be extruded, it is the No. 1 method I could envision; have your least problem with scrap, and as was said, you have a greater opportunity of, in effect, covering up minor defects in the ingot voids.

Senator MALONE. Well, you have been in the manufacturing business for a long time. Your company has been manufacturing a variety of products. Of course, a man of your position watches other factories and manufacturers. Has it been your experience and observation that when a thing is necessary and profitable that generally the laboratories and the research men and production engineers solve most of the problems?

Mr. HOLLOWAY. Eventually; never soon enough to suit me.

Senator MALONE. Perhaps that might apply here. At the same time I am interested in everyone's prediction that it will be a long time. Every once in a while in a laboratory, or a new idea in manufacturing, sometimes they come rather suddenly, don't they?

Mr. HOLLOWAY. Yes, you have the fortune of dropping on something.

So you believe, apparently, that there is a real future in this business. The committee is interested in getting some estimates, not

only the facts of the present use, but the time lag of the availability of the material and when it goes in the air. When the time comes that they don't have to look around and know the material is there in any form they want it, then could you give us some kind of an estimate of what you think this metal might do?

Mr. HOLLOWAY. You mean in demand?

Senator MALONE. Yes.

FUTURE DEMAND FOR TITANIUM

Mr. HOLLOWAY. Tonnage demand?

Senator MALONE. That is right, tonnage demand.

Mr. HOLLOWAY. I am sorry; it will be a rank guess. Do you relate it to aircraft, the aircraft industry?

Senator MALONE. Aircraft industry, and then as the price comes down, as most of us are convinced it will under some voluntary production, into the many civilian uses?

Mr. HOLLOWAY. Well, I believe under present building programs that the aircraft industry today, for warplanes, Government planes, has a demand of at least 30,000 to 35,000 tons per year.

Senator MALONE. Right now?

Mr. HOLLOWAY. Yes, for projected planes.

Senator MALONE. Now, as you heard today, assuming that we keep fooling around until we get ourselves into some kind of a war where we just have to turn the plane makers loose like we have before—did this testimony that you heard this morning from Boeing seem to hit the spot?

Mr. HOLLOWAY. I am sorry. I didn't arrive until after that.

Senator MALONE. General, you could probably repeat the testimony better than I could, under war conditions.

General METZGER. The projected estimate, Mr. Holloway, made by Mr. Hitchcock of Boeing Aircraft Co., was based upon the World War II peak airframe production, which was 1 billion pounds of airframe weight. His estimate on that volume of production was a titanium requirement of 200,000 to 400,000 tons of titanium sponge. He had converted sponge with its attendant loss to ingot in that estimate.

I raised the point, following that statement, that Mr. Hitchcock had been referring to the airframe industry only, and that it was very possible that requirements for engines and equipments could conceivably double that requirement, all of which was based upon a production peak of 1 billion pounds of airframe weight.

I further made the statement, which I think is reasonable, that is, that we can perhaps overlook the World War II production experience and confine our thinking to this line: In any event, material which we engineer into our military weapons within the Air Force should be available in sufficient quantities to satisfy the productive capability of the aircraft industry, recognizing that chances are better than even, in the event of war, that we will call upon the aircraft industry to produce to its maximum capability.

Senator MALONE. Then he estimated the amount of titanium that will be necessarry annually. It was estimated from 200,000 up to 800,000. Well, of course, that covers a great deal of country.

But you are just starting in the business, and in any new business, the best estimate you can get is from the people in it, and that is what we are trying to do.

Mr. HOLLOWAY. I would like to ask the General, first, in speaking of the aircraft industry, do you include guided missiles?

STRATEGIC USES FOR TITANIUM

General METZGER. Yes, because the aircraft industry today is pretty generally the planned source of missile production. I believe it is reasonable to believe that as missiles improve in capability and reach the stage of perfection corresponding to the mission that would be required, it will be a phase-in phase-out operation for military purposes. I mean phase-in of missiles with a phase-out of piloted aircraft. Let's call it piloted and pilotless aircraft.

Mr. HOLLOWAY. I asked that question primarily because it is my—let's call it amateur opinion, from hearsay and discussion—that one titanium aircraft of planned design is supposed to do the work of half a dozen World War II aircraft. So when we take that World War II peak, to the extent that pilotless aircraft may come way up, subject to that, maybe we should take one-sixth of that World War II peak, or whatever number or fraction it is, as to what one of these new ships will do versus the World War II ship.

Senator MALONE. You have this to consider also, and we are all just doing the best we can to look ahead. We started in World War I with one plane to each battery of field artillery. It wasn't very good. It was hardly safe for a stray cat to ride in. But the boys rode in them just the same.

Then we came along to World War II. It was just as new a field as this that we are talking about now. When some body said 50,000 airplanes, some believed it; some didn't. But we reached it.

Now, this time there are great differences of opinion as to how this national defense ought to be conducted. We have foot soldiers in 35 to 45 nations. Some people don't believe there are going to be any foot soldiers, outside of the countries furnishing the foot soldiers. They think that with the guided missiles and your radar and these large bombers and fighters, that we are capable of producing, if we have enough of this metal, that you might be able to do a good deal of your work from here in protecting the areas that you want to protect, especially the Western Hemisphere. Without going any further into that, the methods have a lot to do with it. But it could be the area you are going to cover this time, to control the air, will be even larger.

So your remarks are very helpful in this thing, because it all generates ideas, and that is what the committee will have to decide when they study the testimony.

General METZGER. Mr. Holloway presented the point that aircraft of today or the aircraft of the future are designed to perform more missions than the aircraft of World War II. In other words, he is referring to the point that fewer aircraft may be required than in World War II, and in relating that to the airframe weight, the airframe peak in pounds which Boeing used as a basis for an estimate.

I would like to say it is true that possibly fewer aircraft in numbers are planned than would be required. But it also must be recognized that the aircraft of today weigh considerably more than the aircraft of World War II in themselves, and so the ratio of pounds to numbers is different today and would not be a disparity, and perhaps not be as great as the 5 to 1 that you mentioned, not nearly.

Senator MALONE. General, we don't want to get ahead of you in this business, but some people say if you are going to have airborne troops, you may build bigger planes than even are on the boards at the present time.

That is possible; isn't it?

General METZGER. That is very possible, sir.

Senator MALONE. Most of the information on materials to help get these planes off the ground is classified, anyway, so we can't go much further into it. But we certainly appreciate your appearance here and your interest in the work of the committee.

Mr. HOLLOWAY. Thank you, sir. And I would like to leave one thought: I am a great advocate of a strong Air Force. When I say "strong," I mean insurmountable.

Senator MALONE. The best one.

Mr. HOLLOWAY. Thank you.

Senator MALONE. That completes the witnesses who have appeared from out of town.

It is planned to invite you, General, to make any kind of a summary statement that you care to. We have asked you especially to come here. You have been very helpful all through the hearings, and we lean heavily on you to keep our own feet on the ground. Would you care to make a general statement at this time? Of course, we are not through with you, you understand. We will invite you to Washington when we have further hearings.

General METZGER. Thank you, sir. Senator Malone and Senator Murray, in summary, it seems to me it has been clearly established that titanium is essential in the aircraft presently being planned by the aircraft producers for delivery to the Air Force and to the air arm of the Navy.

It also seems that it has been made clear that titanium is highly desirable for commercial aircraft. From the testimony, I feel that the strides which have been made within the aircraft industry in the development of know-how, for the workability and application of titanium, are short of amazing.

I revert back to last March when the aircraft industry very graciously attended a meeting I called at Wright-Patterson Air Force Base, very similar to this meeting. My objective was very similar to the objective of this committee.

We are well aware, and I particularly in the area of responsibility which I have, that there must be ready and available to industry the tools to produce the products that we demand to support a defense effort or a mobilizational objective, and we are constantly engaged in planning to be sure, to the extent that we are able, that we in time of dire need, in time of war, do not find ourselves in position of critical short supply of any of those tools and, therefore, unable to meet the objectives given to us by the President of the United States.

We have been aware, a few of us—and a few of us, I believe, have been accused of carrying the torch for titanium—I feel that the effort

which we have put forth the past 3 years in an attempt to encourage the development of titanium and encourage the producers of sponge to increase their production and quantity, and improve their quality, have been well justified by the testimony I have been privileged to hear, that has been presented to this committee.

I feel that this committee has within its power an opportunity to make a great contribution to the security of the country. I believe that without quesion we can well find ourselves, in the event of an accelerated production of aircraft, in a position of severe trouble. I don't believe that we can produce the aircraft that we will be called upon to produce and use in the defense of this country unless immediate steps are taken to increase the supply of titanium sponge and immediate steps are taken to further the development, the research, the know-how, in the use and application of titanium.

We, in our area of undertaking as a military department, generally stay away from committing public funds placed at our disposal by Congress in basic materials. We generally commit those funds and use those funds in the development of processes and technological advancements of application of basic materials. We have committed considerable funds in those areas and, as evidenced by a project submitted by the Harvey Machine Co. this morning, we believe that know-how is being developed and developed very rapidly, and that the expenditure of funds in that area is paying large dividends.

Senator MALONE. That was one of your projects this morning?

General METZGER. That is one of our projects; yes, sir.

We must look to other agencies of the Government to further and support the production of the basic materials, and in that area I believe the responsibility rests for the increased supply of titanium. We will and are considering supporting to a minor degree the development of new processes. We are doing it more or less.

Senator MALONE. You are talking about new processes?

General METZGER. In the manufacture of titanium, I should have said. We do it out of a sense of urgency. We don't feel that we properly belong in that field. But unless we are able to secure support or assist in support being granted in those areas by other Government agencies, the urgency, in our opinion, of an adequate supply of titanium will require us to attempt to support the development of new and additional processes in the production of titanium metal.

I believe, Senator Malone, that I have covered my impressions of this meeting. I deem it a privilege to have been here.

I wish to make it a matter of record that the Air Force will assist in every possible way to further the objective of your committee. We are most appreciative of your efforts. We feel that the attainment of your objectives is essential to the performance of the mission assigned to the Air Force.

Senator MALONE. Thank you very much, General.

You understand there are a lot of important things we could be doing besides doing this. I am clear behind in my hunting and everything. [Laughter.]

But we are willing to do it because the Senate charges us with the responsibility. We wanted to be charged with it. I think Senator Murray joins me in that statement.

Senator MURRAY. Yes.

Senator MALONE. To go back to your testimony in Henderson, you estimated that if progress were made as it looks reasonable to suppose it could be made in the production of titanium, and reduction in the price and the variety of uses expanded as it looked like it would, that from 100,000 to 150,000 tons of titanium might be necessary in the foreseeable future annually.

This morning some of the testimony made you sound a little conservative, which I am sure you meant to be.

You do say, as I understand you, General, as all of the testimony in the last 2 days, that the metal is a must?

General METZGER. I honestly believe that.

Senator MALONE. Then it would be a pitiful thing if war should come while we had to ration a very scanty supply of such material, would it not?

General METZGER. It would be short of tragic.

Senator MALONE. We have all witnessed the rationing of materials such as zinc and lead, chromite, and tungsten. One of the largest deposits of the United States is in Montana.

If proper attention had been given to domestic production where we could protect the transportation lines, very little if any rationing would have been necessary

For your information, General, since you did not attend the Washington hearings, the Bureau of Mines engineers—and I am not talking now about someone appointed at the head of a department that might have had engineering training—I am talking about engineers that have spent their lives in a field of metals, like an engineer who has spent his life in a study and production of zinc and lead, for example, and in the precious metals—another matter entirely—but we dug those men out of the Bureau of Mines, and they came before this committee with their heart in their mouth, you might say, because they were so serious in their testimony.

And do you know, they made us a list of materials, about 77 of them, 39 minerals, I believe; and all of those minerals and materials, if proper attention is paid to domestic production and proper attention paid to the Western Hemisphere production on a 3- or 4- or 5-year program, do you know how many of those materials come out that you couldn't be self-sufficient in the production in the Western Hemisphere either through replacement, substitution, or increased production?

Then we had one of my good friends—has been for 25 years—in the Department, Oliver Raleston, who explained at considerable pains how you could cut down the use of industrial diamonds through the use of other methods in the cutting operations and boring and even in diamonds themselves.

Now, all that testimony is available, and from men who know their business; not men who might get it secondhand; and you yourself were in business before you were in the Air Corps. You understand the engineers; I understand them. And I want to say to you and for the record that an engineer who becomes proficient in one or two fields in a lifetime has done mighty well. So he is very careful when he steps out of his field, because he doesn't know.

But the kind of men who have made most of these reports that have been publicized all over the United States and the world, you find them running radio programs and other things. They can talk freely because they have no responsibility.

But this committee is making an earnest effort—Senator Murray himself has come from Washington out here to be here, and other members of the committee will catch up with us as we go along—because we want to hear the facts. We couldn't get the facts any place except forcing these men in the production of airplanes to come to Washington. They have no time to come to Washington, so we come here.

The importance of your testimony, in summation, cannot be underestimated, in my opinion. I want to thank you, General, for coming here, and all of the witnesses who have appeared.

The committee will now stand in recess until 10 o'clock the morning of the 12th in Salt Lake City, where we will resume hearings at that point on the matter of how the work of the committee in rearranging and amending the Oil-Gas Leasing Act of 1920—and coordinating it with the 1872 Mining Act—how it is working out on the plateaus of Colorado and Utah, in the production of uranium ores.

It is the feeling of many of us that, just like the raw material that goes into titanium, we will find ourselves self-sufficient in the production of such material in the United States and Canada or the Western Hemisphere if we apply ourselves.

Thank you all.

(Thereupon, at 4:15 p. m., the hearing was recessed until Thursday, November 12, 1953, at 10 a. m. in Salt Lake City, Utah, for the purpose of taking testimony on uranium.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

MONDAY, NOVEMBER 23, 1953

UNITED STATES SENATE,
SPECIAL SUBCOMMITTEE ON MINERALS, MATERIALS AND FUEL ECONOMICS, OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to call, at 10 a. m. in the committee room, 224 Senate Office Building, Washington, D. C., Senator George W. Malone, Nevada, chairman of the subcommittee, presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee).

Present also: Jerome S. Adlerman, counsel to the subcommittee and George B. Holderer, subcommittee engineer.

Senator MALONE. The subcommittee will be in order.

Let the record show that Gen. Kern Metzger of Wright Airfield, Dayton, Ohio, is present and cooperating with the subcommittee.

The subject that will be covered today and tomorrow is the production of titanium. Titanium metal is little known generally, but has been known to engineers for years.

There was practically no production until recently, when titanium became very important in military aircraft production. It is also very important in commercial planes, but the extent of its use in these planes is to a certain extent dependent on the price. We can have a better plane with the proper amount of titanium. Its use would enable planes to increase their payload by 25 to 35 percent. We have already heard testimony from various experts in the field. The committee held a 2-day hearing in Los Angeles a few weeks ago, when Mr. Douglas of Douglas Aircraft, and Mr. Gross of Lockheed, and representatives of other major companies, including Boeing, presented testimony. Their testimony seemed to agree that even with the present contract price of titanium sponge at about $5 a pound, rolled sheet at about $15 per pound and shapes approximately $20 per pound, its use was still attractive enough up to a certain point. As the price goes down, its use would become more attractive.

Regardless of price, it is probably imperative that it be used in warplanes. Other nations are known to have the knowledge of making titanium, and are making some of it. Therefore it becomes absolutely imperative that our warplanes use titanium.

Right at the moment there is a relatively small amount of titanium being produced. The only two places in the United States where it

is being produced are in New Jersey, by the du Pont Co., and in Henderson, Nev., by the Titanium Corp. The Titanium Corp. is owned by Ludlum Steel and National Lead.

Both corporations have been advanced a considerable amount of money, around fourteen or fifteen million, and each of course has put in a large amount of their own money. But the testimony shows that instead of present production of 2,000 tons per year, if they dared take the plans up-to-date planes were taken off the drafting board, 100,000 to 150,000 tons a year would be needed.

In addition to that, and even more critical, we are dependent for the raw materials at the moment on Australia for rutile, which is being used at Henderson, and to a fairly large extent on India for ilmenite.

Testimony has already shown that the ilmenite is about the fourth most plentiful metallic mineral in the earth's surface. There is absolutely no scarcity. It is a question of discoveries concentrated enough to make it economically available. At the moment it is very evident that there is little difficulty in that regard. At the same time, we are dependent on foreign nations to a large extent for the raw materials.

Few military strategists of my acquaintance believe that we can secure any great amount of heavy material which must be shipped across oceans in surface ships in the next world war, on account of the improvements in submarines and aircraft.

In World War II, I was special consultant to the Military Affairs Committee, and the Secretary of War on strategic minerals and materials, and for a short time with the War Production Board. I recall that the Germans were sinking 80 percent of our shipments of manganese and chromite out of South Africa. If we had not whipped that menace in a reasonable time at the beginning of World War II, we could have lost that war and few people would have understood why.

This committee, in addition to the hearings that will be held today and tomorrow on the matter of production of titanium, and the location, as far as possible, of the rutile and ilmenite necessary for its production, will hear testimony later from military strategists on the lines of transportation that can be kept open when the next world war starts. Many believe that we will have a very hard time securing any amount of this material across either major ocean.

I might say that this ilmenite sand that we are getting from India is from a little subdivision called Travancore in Southeast India, where they pay 11 cents a day for adult labor. For the same labor here we pay $15 a day. And it could be that the competition would be a little keen even if we do have, as it appears now, all the ilmenite we need in this country and Canada.

In the 1934 Trade Agreements Act, Congress transferred to the executive its responsibility of regulating foreign trade, and the State Deparment has injected a political note of helping other nations in the production by dividing our markets with them. Evidence has shown, as of now, that we are now dependent on many nations across 1 or 2 major oceans, or both of them, for a great number of these strategic minerals and materials, without which we cannot fight a war and without which we cannot maintain our economy. It is the

duty of the committee to report to the Senate, after holding hearings, as to what the effect of this past policy has been and what effect this policy has on the availability of these strategic materials in the event of another war.

At this point I will submit for the record a list of the strategic and critical materials.

(The matter referred to is as follows:)

CURRENT LIST OF STRATEGIC AND CRITICAL MATERIALS FOR STOCKPILING

GROUP I. ACQUIRED BY PURCHASE

Abrasive crude aluminum oxide
Aluminum
Antimony
Asbestos, amosite
Asbestos, chrysotile
Asbestos, crocidolite
Bauxite, metal grade
Bauxite, refractory grade
Beryl
Bismuth
Cadmium
Celestite
Chromite, chemical grade
Chromite, metallurgical grade
Chromite, refractory grade
Cobalt
Columbite
Copper
Corundum
Diamonds, industrial
Fluorspar, acid grade
Fluorspar, metallurgical grade
Graphite, amorphous lump
Graphite, crucible grade
Graphite, lubricant and packing grade
Kyanite
Lead
Magnesium
Manganese ore, battery grade
Manganese ore, chemical grade
Managanese ore, metallurgical grade
Mercury
Mica, muscovite block, good stained and better
Mica, muscovite block, stained (radio tube quality)
Mica, muscovite film
Mica, muscovite splittings
Mica, phlogopite splittings
Molybdenum
Nickel
Platinum group metals, iridium
Platinum group metals, platinum
Quartz crystals
Rare earths
Selenium
Tin
Titanium
Tungsten
Vanadium
Zinc
Uranium
Thorium

Nonminerals

Bristles, hog
Castor oil
Coconut oil
Cordage fibers, abaca
Cordage fibers, sisal
Cotton, extra long staple
Feathers and down, waterfowl
Hyoscine
Iodine
Jewel bearings, instrument jewel except vee jewels
Jewel bearings, sapphire and ruby vee jewels
Jewel bearings, watch and timekeeping device jewels
Opium
Palm oil
Pyrethrum
Quinidine
Quinine
Rubber, crude natural
Sapphire and ruby
Shellac
Silk
Sperm oil
Talc, steatite, block
Vegetable tannin extract, chestnut
Vegetable tannin extract, quebracho
Vegetable tannin extract, wattle

GROUP II. ACQUIRED BY TRANFER OF SURPLUSES

Minerals

Bauxite, abrasive
Cryolite, natural
Graphite, crystalline fines
Ilmenite
Mica, muscovite block, stained and lower
Mica, phlogopite block
Platinum group metals, osmium

Minerals—Continued

Platinum group metals, palladium	Selenium
Platinum group metals, rhodium	Zirconium ore, baddeleyite
Platinum group metals, ruthenium	Zirconium ore, zircon
Rutile	

Nonminerals

Agar	Optical glass
Cotton	Pepper
Diamond dies	Talc, steatite, ground
Emetine	Wool

Senator MALONE. On the 30th of this month, we start hearings on petroleum. The same situation is true of petroleum. We obtain petroleum from the Middle East and other nations, and are now rationing production in the oil producing States in the United States.

Today we will start our hearings with Dr. E. A. Gee, vice president of E. I. du Pont Co., Wilmington, Del.

Mr. Gee, will you come forward and have a seat.

STATEMENT OF EDWIN A. GEE, MANAGER OF PLANTS TECHNICAL SECTION, PIGMENTS DEPARTMENT, E. I. DU PONT DE NEMOURS & CO., WILMINGTON, DEL.

Mr. GEE. Thank you, sir.

Senator MALONE. Mr. Gee, you understand the objectives of the committee. We have called you because you have been designated by the company as a person who understands the status of production, the source of the raw materials, and something of the details of production. You may identify yourself for the benefit of the committee, and if you have a statement, you may either read it or comment from it and offer it for the record as a part of your testimony.

Mr. GEE. Thank you, Mr. Chairman.

My name is Edwin A. Gee. For the past 6 months I have been manager of the plants technical section, pigments department, E. I. du Pont de Nemours & Co. Previous to this time I was in charge of research and development on titanium metal for the pigments department. In response to the committee's request for my personal views on present demand for titanium metal, future supply and potential, I am pleased to submit the following information:

RESEARCH BY DU PONT ON TITANIUM

The pigments department of the du Pont Co. undertook scounting research on titanium metal in 1944 and a formal research program was established in 1946. This program culminated in the design and construction of the first of three pilot units in July 1948, and in September of the same year titanium was first offered for commercial sale.

The sole purpose of this limited commercial sale was to try to determine the extent of the potential market for titanium metal. In the case of any new chemical product we must do this to learn at what price, and in what volume, it can be sold.

But let me emphasize that we did not then, nor do we now, have a process which will produce titanium metal at a cost which would justify any large scale expansion for the civilian market.

PROGRESS IN PRODUCTION

Senator MALONE. On what do you base that statement, Mr. Gee?

Mr. GEE. Primarily on two things, Mr. Chairman. First, as I will cover later, we have had no adequate evaluation of the civilian market, because there has been insufficient metal available, due to military demand, to conduct such an evaluation.

Senator MALONE. I understood you to say that there was not a demand for the material.

Mr. GEE. I am sorry, sir. I did not understand you.

Senator MALONE. I say I understood you to say that there was not a demand in the civilian market sufficient to justify manufacturing.

Mr. GEE. That is because we do not know the extent of that market.

Senator MALONE. What you mean to say is that you do not understand the market and you are not sure that there is such a market?

Mr. GEE. That is correct.

The second important point which I will also cover is that the present process, being a batch process, has all of the inherent limitations of batch processes generally and may shortly become obsolete.

Senator MALONE. Why would it become obsolete?

Mr. GEE. This new and infant industry, titanium, is in the very early stages, and major progress is being made technologically, I think the progress over the last 5 years has been virtually without metallurgical precedent. At this rate it appears quite possible that new and improved processes will be developed which will make the present facilities obsolete.

Senator MALONE. Dr. Gee, when I ask you these questions, you are probably aware that we both have some idea of what the answer will be, but I am trying to compile a record for the other members of the committee and for the public.

Mr. GEE. Certainly, sir.

Senator MALONE. Testimony already received by the committee shows a very considerable civilian market, even at the present price. Also you and I both know that the Bureau of Mines and private companies are working very hard on a continuous process, and electrolytic processes and other types. Would you explain, as you go along, or when you finish your statement, what possibility you feel there is of success.

Mr. GEE. Yes, sir; I think I will cover that.

If I may suggest I think in the first three pages of this I will cover the bulk of the important points that you have just raised, and then we can go on from there, if that is all right.

Senator MALONE. Very well. Proceed, please.

OUTLAY BY DU PONT CO. ON RESEARCH

Mr. GEE. The du Pont Co. has already spent more than $4 million for titanium research, and we are continuing this research at a cost to the company of approximately $1 million a year. The major portion of the research is directed toward the discovery and development of a lower-cost process which we believe is essential before there can be widespread military and civilian use.

Anticipating the need for even larger quantities of titanium metal in order to evaluate adequately the market, design for the first semi-

commercial plant was undertaken in 1950 and 1 year later this unit was started up at Newport, Del. This plant had a nominal design capacity of 1½ tons per day, although engineering improvements have permitted operations at 2½ tons per day for the past several months.

The foregoing development program for titanium production was carried forward without Government assistance.

Senator MALONE. I understand you to say that your capacity to product titanium is 2½ tons per day?

Mr. GEE. Approximately.

Senator MALONE. That is your total production?

Mr. GEE. Yes, sir.

Senator MALONE. What does your contract call for?

Mr. GEE. In terms of production?

Senator MALONE. Yes.

Mr. GEE. We have a contract which was entered into on July 24 of 1952 to the best of my recollection in which we are expanding our present privately owned 2½ tons per day plant to a combined capacity of approximately 10 tons per day.

Senator MALONE. Your contract provides for 10 tons per day?

Mr. GEE. No, sir. The contract specifically covers the additional 7½ tons per day.

Senator MALONE. But a total of 10 tons per day?

Mr. GEE. Our contract is only concerted with the additional 7½ tons.

Senator MALONE. That would bring you to 10 tons per day.

Mr. GEE. Yes, sir.

Senator MALONE. The terms of your contract are of no concern to the committee except as to the amount and the price.

Mr. GEE. Yes, sir.

Senator MALONE. I suppose you will cover that as you go along.

Mr. GEE. Yes, sir.

Senator MALONE. Now, it is the understanding of the committee that we have 2 companies producing a total of 10 tons per day. You are one of them.

Mr. GEE. Yes, sir.

Senator MALONE. The Titanium Corp. is another one.

Mr. GEE. Yes, sir.

Senator MALONE. After 3 years, they are producing less than 4 tons per day. It is around 3½ to 4 tons a day. I understand you are now producing a total of 2½ tons per day.

Mr. GEE. Yes, sir.

Senator MALONE. The purpose of the commitee is to show the use of the material which we have already done in our hearings, the extent of the contracts let by the Government, and the cost to the Government and the progress made.

Mr. GEE. Yes, sir.

Senator MALONE. Thank you.

Mr. GEE. Yes, sir.

Senator MALONE. You are producing about 6½ tons, both companies together, Titanium Corp. and du Pont Co., instead of the 20-ton total contracted for.

PRODUCTION CAPACITY OF DU PONT CO.

Mr. GEE. The plant, Mr. Chairman, which we now have under construction was not scheduled to start up until the middle of 1954. The present plant which we are operating, our privately owned plant, is producing, as I said, approximately 2½ tons per day. Actually we have expended considerable sums in improving our technology and I believe for the last few months we have actually produced about 3 tons per day.

Senator MALONE. Then practically speaking, you have not started on the contract with the Government.

Mr. GEE. That is correct.

Senator MALONE. The contract was let July 1952, and you really will not start on the additional production until July 1954.

Mr. GEE. That is approximately correct.

Senator MALONE. The information that the committee is trying to secure for the Senate of the United States is first the importance of the material. According to testimony of General Metzger, who is here today, and very much interested in your testimony, no doubt knowing most of the details already, we need 100,000 tons. So we are not doing very well so far. We would like to find some way to help you or anybody else to produce the titanium, if titanium is as important as the general and many others in the Department of National Defense think it is.

Mr. GEE. Yes, sir.

Senator MALONE. Some other country might beat us to the punch.

Mr. GEE. Total investment by the du Pont Co. for research and initial production now approximates $9 million.

This orderly research and development program, directed toward a low-cost titanium metal process and concurrent evaluation of the civilian market, was sharply revised by the Government's request for construction of additional facilities. On January 13, 1951, based upon the expanding requirements of the Defense Department, Dr. James Boyd, Administrator of the Defense Minerals Administration, requested du Pont to expand its privately owned facilities to 10 tons per day.

Senator MALONE. Right at that point, how much Government money has been furnished to you for such expansion?

GOVERNMENT FINANCING OF DU PONT CO.

Mr. GEE. Our contract called for a Government advance for construction of approximately $14.7 million, which was to be repaid over an estimated 5-year period. We have expended to September 30, 1953, approximately $6 million. We have made advances in our technology and we believe that our final cost to the Government on the advance which we will repay over this estimated 5-year period will be about $11.5 million, or savings of about 3 to 4 million.

In addition to this advance by the Government, we are putting our own funds for operation of the plant in the total of some four to six million dollars.

Senator MALONE. Right at that point, how are you to repay this money?

Mr. GEE. This is an advance which was made by the Government because the expansion that was requested was not practical as a commercial venture in view of the uncertainty of the market that I described, and the possible early obsolescence of the facilities. The Government advanced these construction funds which we were to repay on a poundage payment. For each pound of metal which we produce, we will pay to the Government approximately 60 cents.

Senator MALONE. Explain that, will you please? If you dispose of this metal in the private market and not to the Government——

Mr. GEE. This contract calls for sale to the private market which is made up, as you know, essentially 100 percent by defense requirements.

Senator MALONE. Then the private market would really be a Government market.

Mr. GEE. Yes, sir. That is correct.

Senator MALONE. What price do you get for this material?

Mr. GEE. The present selling price of titanium sponge is $5 a pound.

Senator MALONE. Is that the price that is generally considered standard at the moment?

Mr. GEE. I believe so, sir.

Senator MALONE. That is the price that Titanium Corp. secured. Suppose you did not complete your contract? First, how much of this material are you supposed to produce and during what period of time?

PRODUCTION FIGURES

Mr. GEE. If I may refer to page 5 of my statement I would submit table 2 for the record, Senator, which shows that we estimate reaching capacity production of 900 tons per quarter in the second quarter of 1954.

Senator MALONE. 900 tons per year?

Mr. GEE. Per quarter. In the second quarter of 1954. Our forecast for 1955 is 3,600 tons which is our contract obligation.

Senator MALONE. 3,600 tons for what interval?

Mr. GEE. Per year, sir. Our estimated production for 1954 is 3,460 tons annual basis. I would like to add that our construction is now approximately 8 months ahead of schedule, and we are now carrying out test runs in some of our units preparatory to starting up a plant in the last quarter of 1953.

Senator MALONE. In 1955, you would produce the full 3,600 tons?

Mr. GEE. That is our estimate, sir.

Senator MALONE. How many tons do you have to produce to return the $11.5 million that you think you will use?

Mr. GEE. I think we should differentiate, Mr. Chairman, between the present 2½-ton plant which is not part of our Government contract.

Senator MALONE. And you do not pay 60 cents per pound on that particular production?

Mr. GEE. That is correct. Our contract is concerned with the additional 7½ tons.

Senator MALONE. Let us talk about the 7½ tons.

Mr. GEE. Yes, sir.

Senator MALONE. When are you going to start producing the 7½ tons and when will you reach full production?

Mr. GEE. We expect to reach full production in the last quarter of 1954. That is our forecast. If we produce at that rate for the subsequent 5-year period, we will have repaid the Government advance.

Senator MALONE. What happens to the Government advance if you do not produce that much titanium?

Mr. GEE. That would extend the period under which we would pay poundage payments until the Government's obligation had been fulfilled at 4 percent interest.

GOVERNMENT'S POSITION IN THE EVENT OF DEFAULT

Senator MALONE. Suppose something happened and you did not ever produce an amount that would repay the advance, what happens? Is there a guaranteed return in any other manner?

Mr. GEE. I am not an expert on this contract, but it is my recollection that the facilities are returned to the Government.

Senator MALONE. That is, the facilities that you build for such production?

Mr. GEE. Yes, sir. The money which we invest, which in this combined facility would be some $6 million of our own money, would be lost.

Senator MALONE. And the Government money would be lost.

Mr. GEE. And our own also, sir.

PROCESS USED BY DU PONT

Senator MALONE. That is not a point against the du Pont Co. Do not misunderstand this committee. We want to help you and want to help increase the production if it is as important as General Metzger and others believe it to be. But we do want to know under what conditions, for the benefit of the Senate, the contracts have been let. Is there a clause in your contract that if there should be a new process developed that could make the Kroll——

Mr. GEE. We use magnesium reduction of titanium tetrachloride.

Senator MALONE. Known as the Kroll process?

Mr. GEE. It has been known throughout the Bureau of Mines as the Kroll process. Magnesium reduction of titanium tetrachloride.

Senator MALONE. It is generally known to the public as the Kroll process, is it not? You simply improved the process, but you do not change the batch process.

Mr. GEE. It is a batch process.

Senator MALONE. And you use the same ingredients and perhaps add others, but generally it would be known as the Kroll process.

Mr. GEE. It could be.

Senator MALONE. I think you have gone a good ways for an engineer. Suppose an electrolytic process or some other process were suddenly developed that would make this equipment obsolete, is there a clause in your contract by which the Government absorbs loss for the obsolete equipment? I believe they should, as a matter of fact, in order to ease your mind. I just want to find out for the record what it does do.

Mr. GEE. Yes, sir. You recall that when I read earlier we undertook this expansion at the Government's request and we would not have undertaken it under normal circumstances.

Senator MALONE. I understand all that. I asked you if there is a paragraph in your contract that provides for that.

Mr. GEE. It is my recollection that there is, sir. Under the contract, as I recall, if a new process is developed——

Senator MALONE. It does not matter whether you develop it or somebody else.

Mr. GEE. Yes, sir. If a new process is developed by the industry as a whole, which renders our 7½-ton plant obsolete, and our own as well, I might add, we can at that time request the Government to accept the return of these facilities.

Senator MALONE. It would not be exactly a return. They could just accept the facilities or assignment of the loan.

GOVERNMENT'S POSITION CONTINUED

Mr. GEE. Yes, sir. That is the unamortized portion of the loan that has not been paid.

Senator MALONE. That is what I wanted to show for the record, because if they did not do that, would it not be very unlikely that any responsible company would take a contract when they know that even they themselves are trying to make their own process obsolete?

Mr. GEE. That would certainly be my opinion.

Senator MALONE. I think that is generally held. It is a fact that there is a clause that takes care of all such contingencies.

Mr. GEE. I think it is worth pointing out also, Mr. Chairman, that under our contract we also have a sizable financial stake which could be lost in the event of this obsolescence.

Senator MALONE. I understand that perfectly. For the purposes of the record, this committee is not trying to find fault. It is trying to find ways to help you.

In your opinion, under your present process, what might be the minimum cost for this sponge material or any type of material you might turn out? I am not talking about $5 we know you are going to get under this contract, because we know several people are interested in getting into the business.

Mr. GEE. Mr. Chairman, we are optimistic that when this 7½-ton-per-day plant approaches full production, we will be able to reduce the selling price of sponge. I personally think it is conjectural to attempt to put an exact number on it at this time. I say that for two reasons.

First, we have to assume that we are successful, and secondly, we have no experience in the operation of a titanium metal plant of this size.

Senator MALONE. No one else has either. Is that true? It is a new field.

Mr. GEE. I think that is correct, sir.

Senator MALONE. But you do think it will be materially reduced.

Mr. GEE. Yes, sir, I think it will be reduced.

Senator MALONE. Would you care to say by what percentage?

Mr. GEE. Quite frankly I would prefer not to, because it would be a sheer guess on my part.

Senator MALONE. Are you having any difficulty in producing the quality of material that is required under specifications under the Brinell hardness system?

Mr. GEE. When we first began producing titanium in 1948 we were fortunate if the hardness was under 200 Brinell. At the present time average hardness is below 160 Brinell. I don't mean to imply by that that we have not had quality difficulties. Such are not uncommon in our new product development. I believe, however, that we have satisfactorily met all purity requirements to date, and it is my expectation that we shall be able to continue to do so.

Senator MALONE. You think as you go along in the construction of this additional 7½-ton capacity that as you go along you will whip the problems of uniformity of material, workability of the material and the working of the sheet metal into shapes so they can be used readily?

Mr. GEE. We only produce as far as the sponge is concerned, Mr. Chairman, as you know.

Senator MALONE. But the quality of the sponge has improved markedly?

Mr. GEE. Yes, sir.

Senator MALONE. And it has to do with the quality of the rolled material?

Mr. GEE. Yes, sir. The quality of our sponge has improved markedly as I outlined in answer to the previous question. I think that an improvement will continue to be made and we are directing a sizable portion of our effort to improving the quality of our product.

Senator MALONE. Are you conducting experiments on any other process, that is, a continuous process of manufacture to replace the batch method?

Mr. GEE. Yes, sir, we are expending approximately $1 million annually, exclusive of our investment in plant facilities, and that sum is concentrated in research and development of new processes along the lines that you have just described. We are hopeful that someday we will be able to develop a process which will produce in tonnage at a low cost for a civilian market, and I might add may well be essential for a large military market.

Senator MALONE. Would you explain the Brinell hardness formula for the benefit of the record?

Mr. GEE. Yes, sir. Titanium metal is different from the majority of ferrous and nonferrous metals, in that it is extremely sensitive to small quantities of oxygen and nitrogen. As little as two tenths of 1 percent oxygen or one tenth of 1 percent nitrogen renders the metal virtually useless for most alloying purposes. A test which is conducted to obtain an approximation of the oxygen and nitrogen present is known as the Brinell hardness test, which has been used for a number of years in the steel industry. This test consists simply of polishing the surface of a small piece of titanium metal and obtaining a hardness impression, the size of which is determined. The greater the size, the softer the metal. I would like to insert for the record at this point table 3 on page 7 of my statement, which shows that the metal stockpiled by the Government when it was in excess supply had a Brinell hardness specification of 203. The actual average quality of the metal that we submitted to that stockpile was approximately 168.

Is that satisfactory, Mr. Chairman?

Senator MALONE. Yes, I believe so.

(The table is as follows:)

TABLE 1.—*Actual average quality of all Du Pont metals stockpiled*

	Specifications	Actua laverage quality
Titanium	99.3 minimum	99.7 percent.[1]
Iron	0.25 maximum	0.16 percent.
Nitrogen	0.03 maximum	0.024 percent.
Magnesium	0.10 maximum	0.04 percent.
Chlorine	0.15 maximum	0.10 percent.[2]
Brinell hardness	203 maximum	168.

[1] By difference.
[2] Not available on initial shipments.

Senator MALONE. Does your research program include methods for alloying the material? In other words, alloys for actual physical use in planes and other equipment?

Mr. GEE. It has been my opinion, and the opinion of the Du Pont Co. that we should concentrate our efforts in the fields in which we were best qualified—chemical research. The process as known today and the majority of new processes that we now have under development are chemical in nature, and for that reason we have felt that this is a field in which we should be interested. We do not feel that the fabrication of titanium shapes, sheet, bar alloy sheet, alloy bar, is a field in which we are particularly qualified. For that reason we have stopped our development at the point of producing the basic raw material for the industry.

Senator MALONE. Is not this material, being new, about the same as any other new material developed in the past? In other words, would you not anticipate that titanium will follow in general, the history of, say, aluminum or magnesium? I am not entirely familiar with the history of aluminum, but it was so expensive in the beginning that no one could use it for anything—maybe $50 a pound, 3 or 4 times as expensive as the titanium metal is at the present moment. Would you anticipate that larger production and more laboratory work and the metal coming into general use would result in the price dropping and the quality increasing?

Mr. GEE. Yes, Mr. Chairman, I agree. Obviously we feel that there is a possibility of some day developing a process for a civilian market which can produce in tonnage and at a relatively low price. This is the reason for the very large expenditures which we have made to date.

Senator MALONE. In other words, the history of all new metals follows a pretty definite line of development. Whenever the demand is there, the engineers, scientists and chemists produce the material. Is that not the history of all the metals?

Mr. GEE. That is true, with one qualification that the time varies as a function of the technological difficulty. That pattern has been followed in every case, I think.

Senator MALONE. It also follows the expediency necessary. If all the necessary money were available for such development, and this material is as necessary as it would seem from the hearings already held by this committee, the development of these processes would speed up, would it not?

In other words, suppose there had been no World War II, and suppose there was no threatened emergency at the present time, and development of titanium took its general course, then it might be

25 years instead of 5, or some reasonable time, before you would make even the progress that you are making?

Mr. GEE. There is no question that production can be expedited by large dollar expenditures. I am not at all certain that rapid technical advance can be made on a similar basis. The incentive which has caused this tremendous progress in technology with respect to titanium metal in the last five years, I think, stems from the impetus of free enterprise, and the stimulation of competition. I think that these two things will continue to allow very rapid progress. The large expenditures currently being made by the industry as a whole, I think, are indicative of the faith that industry has in this new product. I think that this progress has been excellent, and I think it will continue to be so, Senator.

Senator MALONE. The hearings so far—and this is the third hearing, first the Titanium Corp. at Henderson, Nev., second the actual and potential users, the major aircraft companies, of this material at Los Angeles and now this one—seem to point to the demand for the material, and that the committee can be helpful in encouraging additional contracts, if the evidence adds up after we complete this hearing and coordinate our report on this particular metal. The people responsible for letting these contracts, realize, of course, that they are taking a chance with Government money. But if it is a national defense requirement, with larger contracts will come additional speed in the making this material available. The committee has felt that it can, then, urge a greater production, that is to say, by recommending that more Government money go into this material. Suppose you were making 50 tons a day, wouldn't such a volume bring down the cost?

Mr. GEE. Usually, yes, sir.

Senator MALONE. Of course, I intend to ask you more questions later but I think you had better proceed with your statement. We will try to bring out whatever has not been made clear at the conclusion of your statement.

Mr. GEE. If I may suggest, Mr. Chairman, I think there are only three paragraphs which might be helpful, and then if I may have permission, I would like to simply insert the balance of the statement in the interest of time.

Senator MALONE. I think that is a good suggestion.

Mr. GEE. You recall that I outlined that our expansion of the 7½-ton plant was not practical as a commercial venture in view of the uncertainty of civilian markets, and the possible early obsolescence of the facilities, and the Government therefore offered to advance the necessary construction funds which were to be repaid over the aforementioned 5-year estimated period.

I also mentioned that a contract to this effect was executed on July 24, 1952, and the plant expansion is now under construction. I am glad to report that construction is about 8 months ahead of schedule and that test runs are now being made in some units of the equipment preparatory to actual production, which is scheduled for the last quarter of 1953.

HIGH COST OF KROLL PROCESS

As of today, I could not recommend to Du Pont management any further investment for production of titanium metal. Present proc-

esses are inherently high in cost. The present market for titanium metal is essentially 100 percent military, and the actual size of the civilian market is unknown. Finally, the present process has all the disadvantages of batch processes generally and would rapidly become obsolete if improved methods are developed.

In view of these considerations I feel that from an economic point of view we should not expand at the present time but should devote our efforts to the development of processes having inherently greater promise of providing titanium at prices more nearly commensurate with the long-range requirements of the civilian and military fields.

If, in the opinion of the Government, the interests of national defense cannot be met in this fashion, undoubtedly the Du Pont Co. would give prompt and serious consideration to Government proposals directed toward further expansion. Obviously I am not in a position to evaluate the military supply and demand situation—except to the extent that such data are supplied by Government agencies.

It is my understanding that in March of this year Du Pont was requested by DMPA to discuss the possibilities of further expansion to meet national-defense needs. In a conference with DMPA officials on March 23, 1953, and again on April 2, 1953, the Du Pont position was outlined and at that time they expressed their willingness to expand if requested to do so by the Government on the basis of national necessity. It is my understanding that subsequent to these discussions the entire titanium program has been under review by the Department of Defense.

I would like permission if I may, sir, that the entire statement be included.

Senator MALONE. It will be accepted in the record as part of your testimony at this point.

PRESENT AND FUTURE DEMANDS

Mr. GEE. The committee has requested my ideas on present and future demand. The Du Pont Co. supplied 303 tons of titanium to a revolving stockpile during 1952 and 1953. At the present time, however, because of military demand we are oversold, and it is my understanding that the stockpile has been virtually depleted. It is anticipated that this situation will continue, at least until the expanded facility reaches full production.

There appears little question that, if the selling price of titanium could be lowered, a sizable civilian market would exist. Tonnage estimates at varying price levels are purely conjectural, since no accurate market forecast has been possible in the absence of a supply of metal for civilian evaluation. Production which normally would be channeled into such markets has been necessarily diverted to defense requirements.

Present demand is, of course, a direct function of defense requirements, and I have available only published information on military planning.

Our production record, together with national production as reported by the Bureau of Mines is tabulated in table 2.

TABLE 2

	Du Pont annual tons	Total United States annual tons [1]		Du Pont annual tons	Total United States annual tons [1]
1948	3	10	1951	356	495
1949	14	25	1952	727	1,100
1950	52	75	1953	[2] 900	[2] 2,000

[1] Reported by Bureau of Mines.
[2] Estimated.

The rapid increase of Du Pont production subsequent to 1950 reflects the efforts of the company to meet stepped-up military demands following outbreak of the Korean war.

As far as forecast production from the expanded Du Pont plant is concerned, data are shown in table 3.

TABLE 3.—*Forecast production*

	1954—tons	1955—tons
First quarter	760	900
Second quarter	900	900
Third quarter	900	900
Fourth quarter	900	900
Annual total	3,460	3,600

It may be of interest briefly to consider the reasons for high quality requirements in titanium metal sponge. Titanium, unlike the conventional ferrous and nonferrous metals, cannot be refined for the removal of nitrogen and oxygen. When these elements are present, there is no known method for their removal, and unfortunately they have a tremendous effect on physical properties. As little as one-tenth of 1 percent nitrogen or two-tenths of 1 percent oxygen render the metal virtually useless for most purposes.

Tremendous progress has been made in the quality of titanium metal produced. In 1948 we were fortunate when the quality of metal manufactured was under 200 Brinell; at the present time average hardness is below 160 Brinell. I do not mean to imply that we have not had quality difficulties—such are not uncommon in new product development. I believe, however, that we have satisfactorily met all purity requirements to date and it is my expectation that we shall continue to be able to do so.

During 1952 and early 1953, as previously mentioned, 303 tons of metal produced by the Du Pont Co. were purchased by the General Services Administration at the request of the Defense Materials Procurement Agency. This revolving stockpile or reserve was purchased for resale and was in no way connected with the national stockpile of essential materials. The revolving purchase and resale program was established to maintain capacity operation of sponge manufacturing facilities during the development period of military applications. I would like to use, as an example of past quality, the specifications under which Government purchases were made together with the actual average quality of the 303 tons submitted.

TABLE 4.—*Actual average quality of all Du Pont metal stockpiled*

	Specifications	Actual average quality
Titanium	99.3 minimum	99.7 percent.[1]
Iron	0.25 maximum	0.16.
Nitrogen	0.3 maximum	0.024.
Magnesium	0.10 maximum	0.04 percent.
Chlorine	0.15 maximum	0.10 percent.[2]
Brinell hardness	203	168.

[1] By difference.
[2] Not available on initial shipments.

In closing this statement, I think it is in order to give credit to the farsighted research program of the Bureau of Mines which led to this unprecedented expansion in titanium metal. The Boulder City, Nev., laboratory of the Bureau of Mines has pioneered many titanium metal developments and its program of publicizing the metal's unique metallurgical properties and potential applications has stimulated private industry's present program. Special recognition should be given to Mr. F. S. Wartman of the Bureau of Mines who supervised the bulk of the initial research.

Senator MALONE. You touched civilian uses. Do you have any research department that goes into the question of civilian use of this material?

CIVILIAN USES FOR TITANIUM

Mr. GEE. Yes, sir. In 1948, when we first started up our first small pilot unit, it had the specific objective of evaluating the possible civilian market. Military demand particularly subsequent to Korea has grown at such a rate that we have had almost no metal available in the past few years for civilian market evaluation. Even though metal was temporarily stockpiled it was at that time earmarked for subsequent requirements. In the absence of metal for actual field evaluation, it is virtually impossible to obtain good estimates of the civilian market.

FABRICATORS OF DU PONT'S PRODUCTION

Senator MALONE. Where is your market for this material now? To whom do you sell?

Mr. GEE. We sell to a number of companies, such as Rem-Cru Titanium. We sell the sponge which these companies fabricate. It is my understanding that the product of these companies essentially goes completely to the Air Force.

Senator MALONE. But you do not know, really?

Mr. GEE. No, sir, I do not have accurate data since we are one step removed from these sales.

Senator MALONE. What does your contract provide in the matter of sales? Does it simply provide that if you do not find a market for it, that the Government will take it at a certain price?

Mr. GEE. The Government has that option in the event that an adequate market does not exist. I might add, Mr. Chairman, that production normally increases in a series of steps while demand grows gradually over a period of time. There are frequently periods in

the development of a new product where there is a temporary excess of supply. That situation existed in 1952, when we stockpiled some 303 tons.

Senator MALONE. That is the Government purchased a certain percentage of your output?

Mr. GEE. Yes, sir. That is one of the main reasons we have that arrangement in the contract.

Senator MALONE. In other words, instead of the Government having the option to purchase, you have the option to sell it to them in the event you do not have another outlet?

Mr. GEE. The Government has the option to buy. We have to offer it to them if we can not sell it elsewhere. It is the Government's option.

Senator MALONE. Regardless of whose option it is, you would have to keep it and stockpile it yourself if you had no private sale, unless the contract contained a provision that you could sell it to the Government for $5 a pound?

Mr. GEE. Yes, sir, that is a very important provision considering the high value of titanium metal; the amount of money which would accumulate would be very large indeed over a very short period of time if one were forced to stockpile.

Senator MALONE. That is true. Speaking as only one member of the subcommittee, I heartily agree that they must do that. I wanted to make it clear for the record that the Government is forced to accept any such material you offer to them at $5 per pound if it meets the specifications.

Mr. GEE. I am not certain that is my recollection of it. I might add that this is to be sold at $5 or market, whichever is lower. In other words, if the market dropped below $5, then we would be forced to sell at that figure.

Senator MALONE. On that point right now, the demand so far exceeds the supply that as a mater of fact you could probably get more than $5 for it. Is $5 the maximum that you can sell it for, or do you have to sell it at the market when it is below that?

Mr. GEE. At the maximum of $5 or the market, whichever is lower.

Senator MALONE. As a matter of fact, does not the demand so far exceed the supply at this moment that there is no danger of it going below $5?

Mr. GEE. It is our objective, Mr. Chairman, to lower the price as rapidly as we can. That obviously is in the best interest of all concerned. Our program in this direction, as I mentioned earlier, was that when the new facility, the 7½-ton facility, approached capacity operation, we would be able to lower the price, regardless of the oversold condition of the market.

Senator MALONE. That is a mater of your company policy. What I am trying to bring out for the record is this. Is it a fact that any time you do not get $5 for it, according to the contract the Government will take it?

Mr. GEE. They have that option, that is correct, sir.

Senator MALONE. Let us put it the other way around. Suppose you offered it to the Government at $5 and someone else offered $4.90 for it; the Government has to take it under your contract. I am only interested in the one point.

Mr. GEE. I realize that. I want to be correct, sir, and I don't recall that.

Senator MALONE. Do you have a copy of the contract with you?

Mr. GEE. Yes, sir. It is a long contract. Let me refer to my index.

Senator MALONE. I think you will find that under your contract any time you cannot get $5 a pound for it, you can sell it to the Government. That is all I want to know at this point. There will always be a sale for it at less than $5, even at $2.50, but you could not sell it at $2.50 according to your testimony.

Mr. GEE. I cannot find that reference.

Senator MALONE. Does it not seem reasonable to you that is the way it reads?

Mr. GEE. It may well be.

Senator MALONE. Will you submit a statement this afternoon, undoubtedly you can find it by then, as to whether or not it is true that if you are unable to dispose of your sponge on the Government-financed facilities, that is, you put some of your money into it too, no doubt, but the expanded facilities, at $5 a pound, even if you could get $4.99 for it, you can still sell it to the Government for $5? Will you supply that this afternoon for the record?

Mr. GEE. I would be glad to, sir. (See letters, p. 347.)

Senator MALONE. Now I would like to ask you if you have any allocation plan, or if you just sell it wherever the market happens to be, and if there is any limit to where you can sell it in your contract?

Mr. GEE. In our contract, I believe we are first required to attempt to sell it to industry.

Senator MALONE. Are you restricted to any selected industry producing war material, or can you sell it to any purchaser?

Mr. GEE. To the best of my knowledge, all of the material which is currently being produced is being disposed of with Government guidance. We have had innumerable meetings with representatives of the Air Force, and other Government agencies, and we have been guided by their advice on the distribution.

Senator MALONE. Let me ask you the question in another way. Must you take the Government advice as to where the material should go, and if you cannot dispose of it where they say, must the Government take it?

Mr. GEE. I am not sure I got the whole question.

Senator MALONE. I will simplify it. If you cannot dispose of it for $5 per pound where the Government indicates it should go, then are you forced to sell it to other purchasers, or must the Government buy it at $5 per pound and put it in the stockpile or whatever it chooses to do with it.

Mr. GEE. It is my recollection that the procedure that is followed is that our production is sold to industry if at all possible. If industry does not purchase it, I believe then we must offer it to the Government.

Senator MALONE. Must the Government take it?

Mr. GEE. I am not certain of this, which was the point we discussed before. It is my recollection that the Government accepts it or we are allowed to return the plant to the Government for their use.

Senator MALONE. Yes. In other words, you just turn the whole facilities over to the Government for the loan it made to you.

Mr. GEE. Yes, sir.

Senator MALONE. When you get into production next year and the Government suggests where you dispose of this material, and those people cannot pay $5, you can then offer the titanium to the Government. But can you sell it to other purchasers whom the Government does not suggest? Does your contract prohibit such a sale?

Mr. GEE. This is my recollection, Mr. Chairman, I will have to be frank. It is my recollection that the contract does not deal with that particular point, but that as a practical matter titanium metal is now under military allocation. We have no option, and we would not attempt certainly to exercise one to sell any of that metal other than where the Government should desire it to go.

Senator MALONE. I think that is a correct answer, and I believe now it is under military allocation, is it not, General?

General METZGER. In part; yes.

Senator MALONE. But not altogether?

General METZGER. No, sir.

Senator MALONE. Let us assume that 5 or 10 percent is not under allocation, are you limited as to whom you can sell? Does the Government have to indicate to whom you can sell it? Do you have to follow its suggestion if it is not under military allocation?

Mr. GEE. I really don't know.

Senator MALONE. That is another point. Will you find that out this afternoon and give it for the record.

Mr. GEE. Yes, sir.

(The information is as follows:)

E. I. DU PONT DE NEMOURS & CO., INC.,
Wilmington 98, Del., November 25, 1953.

HON. GEORGE W. MALONE,
Senate Office Building,
Washington, D. C.

Dear Senator MALONE: This has reference to several questions which arose during my testimony before the minerals, materials, and fuel economic subcommittee of the Committee on Interior and Insular Affairs on November 23. The committee requested certain additional information on the following topics:

1. *Exports of titanium metal sponge.*—A complete list of our exports since initial sale of titanium metal in 1948 is attached. The total of 2,052 pounds is less than 0.1 of 1 percent of our total production.

2. *Self-sufficiency of North American with regard to titaniferous raw materials.*—It is our opinion that sizable raw material reserves are available on the North American continent. Deposits in Canada, Virginia, New York State, and Florida are now being operated.

In our opinion these deposits will support a sizable increase in titanium metal production, but until a firm figure of need is established we are not in a position to state that the present sources will support the required tonnage. In addition to these deposits other reserves, such as are now known to exist in California, will undoubtedly be discovered.

We wish to point out, however, that numerous technical and economic problems remain to be solved before the present Du Pont titanium sponge metal process can utilize some of the raw materials currently available.

As an example, the Allard Lake deposit in Canada is currently under exploitation by the Quebec Iron & Titanium Corp. This deposit is reported to contain approximately 500 million tons of ore which averages about 30 percent titanium dioxide content. The foregoing organization has developed a smelting technique whereby high titanium dioxide slag is produced. Even this material, however, when upgraded to 70 percent titanium dioxide content through smelting, has inherent technical problems which must be solved before it can

be successfully utilized in the manufacture of titanium sponge metal by the current Du Pont process. None of these problems appear to be insurmountable.

3. *Imports of ilmenite from India.*—As I advised, we are expanding our operation in Trail Ridge, Fla., because of the uncertainty of imports. Over the past 3-year period we have found it to be increasingly difficult to obtain ilmenite from India, probably due to the following factors:

(*a*) The Indian producers may be oversold.

(*b*) Part of the industry has been nationalized, increasing the complexity of negotiations.

(*c*) Output at the Indian producing plants undoubtedly has been reduced due to the fact that the Indian Government has imposed more stringent monazite specifications on ilmenite exports.

In brief, increasing difficulties in obtaining required quantities of Indian ilmenite have led us to expand our domestic sources.

4. *Sale of sponge to the Government.*—During negotiation of the contract between the Government and Du Pont, it was emphasized that the Government would not commit itself to take the output of the additional facilities for the 5-year period. On the contrary, the Government desired to limit its risk to the cost of the additional facilities (estimated at $14,700,000). Article III, section 4 of the contract obligates the Government, if requested by Du Pont, to buy that part of 675 short tons of sponge, produced by the additional facilities for each calendar quarter, not freely bought by the Government or otherwise sold or utilized by Du Pont. If there should be no other sale or disposition of sponge, the Government would thus be obligated by this provision to take the entire 675 short tons per calendar quarter of sponge. However, article VI, section 2 of the contract provides that, as to such purchase, the Government will not pay cash, but will credit the price against Du Pont's indebtedness for advances and accrued interest. It would be possible, if there were no market for sponge, for the Government to be required to buy sponge until advance (plus interest) were all paid in sponge. Thereafter the Government is relieved of this obligation to buy sponge (art. III, sec. 4, last sentence). The net effect is that the Government's liability under these provisions does not exceed the costs of the facilities (plus interest) and is offset by the sponge which the Government would receive. In other words, Du Pont may pay its indebtedness in sponge instead of in cash.

5. *Relation of ore cost to sponge metal price.*—As I testified, the cost of ore itself is a relatively minor factor in titanium metal selling price. Extensive processing of the ore is required, however, before it can be converted to a usable intermediate. The complexity of this processing has a much more appreciable effect on final metal selling price than the basic ore cost.

As you are aware, impurities in the ore increase as the titanium dioxide content decreases. This results in processing losses and requires equipment modification. While we have never operated a titanium metal plant with marginal or submarginal ore, limited data indicate that sizable cost penalties and capacity losses would result after the technical problems were overcome.

Discussions with our engineers and chemists led to the conclusion that we cannot reliably predict the relationship between lower grade ores and selling price of sponge metal in the absence of direct experience in this field.

I trust the foregoing adequately answers the various questions raised.

Very truly yours,

E. A. GEE,
Manager, Plants Technical Section.

Exports of titanium metal, Du Pont

Year	Amount, pounds	Country	Year	Amounts pounds	Country
1948	3	Canada.	1950	50	England.
1949	25	Switzerland.	1951	50	Canada.
1949	1	Canada.	1951	50	Do.
1949	5	Do.	1951	1,000	England.
1949	2	Holland.	1952	50	Canada.
1949	10	England.	1952	10	England.
1949	28	Do.	1953	250	Canada.
1949	2	Canada.	1953	15	England.
1949	1	Do.	1953	1	Japan.
1949	1½	Switzerland.	1953	50	Germany.
1949	250	England.			
1950	135	Canada.	Total	[1] 2,052	

[1] Less than one-tenth of 1 percent total production.

E. I. DU PONT DE NEMOURS & CO., INC.,
Wilmington 98, Dela., December 8, 1953.

HON. GEORGE W. MALONE
Senate Office Building,
Washington, D. C.

Dear SENATOR MALONE: During the course of my testimony on November 23 before the minerals, materials and fuels economic subcommittee of the Committee on Interior and Insular Affairs, the committee requested additional information on certain questions. After having had an opportunity to review the stenographic transcript of the hearing, I find three additional items that were not covered in my reply of November 25.

1. *Sale of sponge to industry and Government.*—Under the terms of our contract we must offer sponge produced to the Government if sales to industry are inadequate to justify capacity production (art. III, sec. 3). The price which the Government would pay for such sponge is the selling price quoted by the Engineering and Mining Journal, metal and mineral markets, or $5 per pound, whichever is lower (art. IV, secs. 1 and 2).

2. *Sale to industry.*—As I indicated, our sales to industry are guided by various Government agencies, particularly the desires of the Department of Defense, and as a practical matter titanium is now under military allocation. This is not specifically stipulated in our contract other than under article II, section 2, where industry sales are made subject to priority delivery as may be required by law. It is our practice, however, to follow the recommendations of appropriate Government agenices concerned with the distribution and utilization of titanium metal.

3. *Importation of ilmenite.*—In addition to ilmenite imported from India, some material in the past has been imported from Canada and Norway.

In reviewing the transcript, I have also noted a number of stenographic errors. Without attempting to list all of these errors, the committee may wish to correct the following items which, I believe, are the more important ones:

Page 11, line 17, correct July 1, 1952 to July 24, 1952.

Page 15, line 14, the conjunction "and" should follow the comma.

Page 18, last line, "titanium tetrachloride" is the correct term rather than titanium dioxide.

Page 19, line 4, "titanium tetrachloride" is the correct term rather than titanium ore.

Page 36, line 13, should read, "* * * a very important provision considering * * * " rather than "* * * a very important provision of * * *"

Page 44, line 21, should read, "less than one-tenth of 1 percent * * *" rather than "one-tenth of 1 percent * * *"

Page 56, line 6, should read, "It is a very short distance of about 50 miles to the Sorel smelter and about 600 miles to the Allard Lake ore body."

This letter will also serve to confirm my telephone conversation of November 27 regarding the production of our first batch of titanium metal in the new plant on November 24. Only part of the additional facilities are now in operation, but a revised estimate indicates that capacity production will be reached within approximately 4 months.

A new production forecast is now available and is tabulated below. This represents an estimated increase in 1954 production of 823 tons, and also indicates that we expect to reach capacity operation in March 1954 rather than October 1954. The committee may wish to substitute this latest forecast for the one appearing on page 32 of the transcript.

Forecast production

	1954	1955
	Tons	*Tons*
1st quarter	760	900
2d quarter	900	900
3d quarter	900	900
4th quarter	900	900
Annual total	3,460	3,600

I trust this additional information answers all of the questions raised during my testimony on November 23.

Very truly yours,

E. A. GEE,
Manager, Plants Technical Section.

General METZGER. Senator Malone, if I may, I should like to perhaps answer your question in more detail.

COOPERATIVE AND VOLUNTARY ALLOCATION OF TITANIUM

Senator MALONE. I would like you to very much, because it is a very important question, as I will bring out later.

General METZGER. The supply of titanium metal today is being allocated voluntarily by the producers at the request of the Air Force, and along specific channes provided by the Air Force. To the best of my knowledge there is no involuntary allocation, or in other words, a regulation which requires a producer to follow the recommendations of the Air Force. It is purely at this point a voluntary undertaking on the part of both.

Senator MALONE. Do you happen to know, General, if the firm to whom it is allocated will not or cannot pay $5 per pound, can du Pont be forced to sell it, or can du Pont offer it to the Government? In that case is the Government bound to buy it for the stockpile?

General METZGER. I really am not familiar with that.

Mr. GEE. I think the answer to that, Mr. Chairman, would be that if the market price, which would be established by this lower than $5 sale, existed, then we would under the terms of our contract necessarily offer it to the Government at the same price.

Senator MALONE. But are they bound to buy it? I know you can offer it to them. Under your contract are they bound to buy it?

Mr. GEE. That is the point I am going to obtain the information on.

Senator MALONE. You will get the information for the committee.

Mr. GEE. Yes, sir. (See preceding letter.)

Senator MALONE. One purpose of the question is that it developed that the Titanium Corp. is selling their product to certain companies, and a certain amount is being shipped to England. As a matter of fact, if it is not prohibited by your contract, and the Government is not bound to buy it, and refuses to buy it, you could ship it to any place in the world. I would like to know about that.

Mr. GEE. I would like to say that less than one-tenth of 1 percent of the metal which we have produced in our privately owned facility has been exported.

EXPORTS OF TITANIUM

Senator MALONE. Less than 1 percent?

Mr. GEE. Less than one-tenth of 1 percent has been exported. In general these were small shipments for research use and in many cases were made only at the request of a government agency.

Senator MALONE. Where did they go?

Mr. GEE. They went to Canada, Great Britain, I believe there was one small amount—and these are pounds, Mr. Chairman, because the total was less than a tenth of 1 percent—that went to Switzerland and I don't recall the balance. To the best of my knowledge none of this material was ever exported to an Iron Curtain country.

Senator MALONE. We will call England a non-Iron Curtain country. You would have no control over its reshipment after it went to Switzerland, England, or Canada?

Mr. GEE. That is correct. For that reason we have been very careful in our exports, and have been making them only after careful consideration with the Government agencies involved.

Senator MALONE. What Government agency do you work with in that connection?

Mr. GEE. I am not certain as to what steps are involved in each case, but I know that certain permission must be obtained in terms of export licenses and I know at least in some cases we have discussed it with the Defense Department. I am not sure that is true in every case.

Senator MALONE. Do you have any recollection of sending any to Japan?

Mr. GEE. No, sir; I do not. I will be glad to check that if you would care to have that information.

Senator MALONE. I would like for you to check and give us a complete list of the nations to which you have sent this material.

Mr. GEE. Yes, sir.

(The information is contained in letter, p. 347.)

Senator MALONE. We are importing some of the material from Japan, and the information we have is that it is very good material. Do you know of any other countries in production now besides Japan and where we may purchase it?

Mr. GEE. I do not know, sir. There have been statements in the technical press, I believe, that Great Britain has undertaken research in titanium. But I have on factual information on that.

Senator MALONE. There is evidence that they are either just getting into production or preparing for production. Of course, we see continual advances in Japan and other nations in Europe that are making additional trade agreements. It would seem they already have enough trade agreements but they are making additional trade agreements with Communist China and other nations. I was interested in knowing whether you have any control after you sell it to a foreign nation.

Mr. GEE. No, sir, to the best of my knowledge, we do not. I am not certain of that point.

Senator MALONE. Where do you secure your raw material for your production?

DOMESTIC ILMENITE USED IN DU PONT'S PRODUCTION

Mr. GEE. We secure it domestically from our deposits at Trail Ridge, Fla. We are self-sufficient with regard to both our metal and pigment production. The uncertainty of imports, Mr. Chairman, led us to open another deposit in Florida this year. We are currently producing about 100,000 tons per year of ore, and expect to double that figure, which will allow for some increase in titanium metal production.

Senator MALONE. What is this, rutile or ilmenite?

Mr. GEE. This material is known as a mixed mineral and is composed primarily of ilmenite, about 85 percent, with some small quantity

of a weathered form of ilmenite known as leucoxene. It is primarily ilmenite and would probably in the language of the layman be called ilmenite.

Senator MALONE. Would you explain for the benefit of the record the difference between rutile and ilmenite?

Mr. GEE. Yes, sir. Rutile is essentially titanium dioxide, and to the best of my knowledge is in relatively limited supply for large-scale production.

Senator MALONE. In this country?

Mr. GEE. In this country. I believe the vast majority of the rutile produced is consumed in coatings for welding rods in defense applications in time of national emergency.

Ilmenite on the other hand is a mixed oxide of iron and titanium, therefore contains less titanium, but is much more abundant, and is in relatively good supply in this country.

Senator MALONE. You say rutile is in short supply. The foreign nations which produce it are not in short supply, are they?

Mr. GEE. I am not familiar, Mr. Chairman, with the situation on foreign supplies of rutile.

Senator MALONE. We had testimony from a representative of Australia that they have all the rutile we could ever use, and naturally they are looking for a market for titanium, just like the wool from Australia and wheat from Canada and petroleum from the Middle East, and all these other materials. That is a natural thing, if they can supply all of our needs. But you say that the rutile is the only supply we have in this Nation?

Mr. GEE. Ilmenite.

Senator MALONE. Do you produce any rutile in Florida or any other area of your production?

Mr. GEE. No, sir. There are small quantities of rutile mineral which are not separated to the best of my knowledge which may go through the process, but they are insignificant.

Senator MALONE. In one of our prior hearings someone believed you had a rutile deposit in Florida, also.

Mr. GEE. That is not correct, to the best of my knowledge, Mr. Chairman.

Senator MALONE. Where are you securing your other material that you do not produce yourselves, that is, your own company?

Mr. GEE. Our raw materials for titanium metal manufacture are ores which I mentioned were obtained from our own Trial Ridge deposits.

Senator MALONE. Where is Trial Ridge located?

Mr. GEE. In Florida, generally around, you might say, the Jacksonville area. We purchase the magnesium which we consume in our process. We have done this, Mr. Chairman, because we do not feel that at the present time it would be economic to construct a magnesium cell plant and in addition magnesium has been available on the market.

Senator MALONE. There is no scarcity of the raw material to produce magnesium?

Mr. GEE. Yes, sir.

Senator MALONE. That comes from sea water and other materials very plentiful in this Nation, is that true?

Mr. GEE. We also utilize chlorine, and that is purchased.

Senator MALONE. How do you spell that?

Mr. GEE. C-h-l-o-r-i-n-e. We also purchase chlorine as available in the market.

Senator MALONE. There is no scarcity of chlorine.

Mr. GEE. In time of national emergency there would be a scarcity. There is not at the moment.

Senator MALONE. Would there be a scarcity in wartime if enough plants were constructed in advance?

Mr. GEE. No, sir. If plants were constructed, I think that would adequately answer it.

Senator MALONE. Do you have any knowledge of how long it takes to construct a plant?

Mr. GEE. No, I am not acquainted with chlorine technology.

Senator MALONE. There is no scarcity of raw material to produce chlorine, is there?

Mr. GEE. No, sir.

Senator MALONE. Then if we become dependent on any other area for chlorine, it would be sort of our own fault, would it not?

Mr. GEE. That certainly seems to follow.

Senator MALONE. Do you get any other material like your ilmenite from any other area?

Mr. GEE. As I mentioned, Mr. Chairman, we had in the past imported ilmenite from India and from other sources whenever it was available.

Senator MALONE. Where are the other sources?

Mr. GEE. I do not have that information.

Senator MALONE. Would you complete the record?

Mr. GEE. I would be glad to supply that. (See letter, p. 347.)

Senator MALONE. You see, the work of the committee is to assure the availability of strategic and critical materials in wartime.

Mr. GEE. Yes, sir. The uncertainty of foreign sources was the prevailing factor in our opening up these domestic deposits in Florida.

Senator MALONE. Was this uncertainty in peacetime the reason that you are developing your own materials as much as you can?

Mr. GEE. Both, sir.

Senator MALONE. What would be the uncertainty in peacetime?

Mr. GEE. I am far from expert in the field of foreign relations. In fact, I know nothing about it. I believe it has been more difficult to obtain large shipments of ilmenite from India in the last few years.

Senator MALONE. Does it have anything to do with the neutral position India might have taken in other conferences?

Mr. GEE. It could be.

Senator MALONE. You have no knowledge why it is a little difficult to get the material from India?

Mr. GEE. No, sir.

Senator MALONE. Did you have any difficulty in the beginning in getting material from India?

Mr. GEE. I believe in the past we obtained the bulk of the material from India in years gone by.

Senator MALONE. If you know, can you say whether there is any scarcity of such material in India? Would that be the reason they did not want to part with it? Are there other reasons? Is it in ample supply in India?

Mr. GEE. Again I am not well informed, Mr. Chairman, but I believe it is in plentiful supply.

Senator MALONE. Then if there was any short supply from India in peacetime it would be a matter of policy, in not sending it to us.

Mr. GEE. In all probability.

Senator MALONE. Would that be your conclusion?

Mr. GEE. I am not informed sufficiently to draw an accurate conclusion.

Senator MALONE. Do you have anyone in your organization who could give you information that deals directly with such supply?

Mr. GEE. I would be glad to find out, sir.

Senator MALONE. You must have. What department in your organization deals with the supply of raw materials?

Mr. GEE. The supply of ilmenite raw material would be primarily the province of the pigments department, with which I am associated.

Senator MALONE. You are not associated with the purchases?

Mr. GEE. I am not in the purchasing department.

Senator MALONE. Who would need to appear here and give us the details?

Mr. GEE. I really don't know. I will be glad to find out and let you know.

Senator MALONE. Would you let us know, and not only that, but perhaps a statement from them in some detail as to its availability, providing the Indian authorities wanted to allow us to have it, whether it is in plentiful supply, and what is the reason for the difficulty in securing it in peacetime?

Mr. GEE. Yes, sir. (See letters, p. 347.)

Senator MALONE. Your difficulty of securing it even in peacetime prompted you in part at least in developing local material?

Mr. GEE. Yes, sir.

Senator MALONE. What chances do you believe you would have to secure this material, in an all-out war?

Mr. GEE. I would imagine it would be very difficult. It was my recollection that during the last war we had a great deal of difficulty importing bauxite from the Guianas through the Caribbean, which was a relatively short distance in comparison to the haul from India. I would imagine it would be most difficult.

Senator MALONE. Could you give us some idea of the availability of ilmenite material in the United States and Canada?

Mr. GEE. There are very large amounts of titaniferrous minerals in the United States and Canada; as I mentioned earlier they are primarily ilmenite containing various percentages of titanium oxide. It is an economic problem as to what grade of ilmenite one uses at a particular moment. Obviously it is most economic to use the best grade available. However, if one takes into consideration the very large deposits, particularly in the Allard Lake region of Canada of low-grade ilmenite.

Senator MALONE. How far is that from the boundary of the United States and Canada?

Mr. GEE. It is a very short distance of about 50 miles to the Sorel smelter and about 600 miles to the Allard Lake ore body.

Senator MALONE. As long as public relations are like they are now between Canada and the United States, there would be no difficulty of securing the material at any time.

CANADIAN DEPOSITS OF ILMENITE—QUANTITY AND GRADE

Mr. GEE. I would assume that would be correct, yes, sir. With this large deposit which is as I mentioned below the grade normally utilized, some companies have undertaken its exploitation on it, and I understand have developed beneficiation processes which are very promising. This deposit will be a major source of our raw material for titanium metal manufacture for many years to come.

Senator MALONE. As a matter of fact, does not this ilmenite occur in iron ores that are very plentiful in Canada and the United States? If the titanium production reached the magnitude that General Metzger has testified would be necessary for national defense, and then the testimony in Los Angeles from the airplane-production companies substantiating and enlarging that testimony, that if we went into the manufacture of planes as we did in World War II, that production might double or treble, then is it not a fact that the demand for the ilmenite would help make the iron-ore production for steel a feasible operation?

Mr. GEE. I think that is true, Mr. Chairman. I believe that the beneficiation process, as an example, which is currently visualized for this Canadian deposit will produce in addition to a high titanium slag a form of pig iron.

Senator MALONE. Which is used in our steel production?

Mr. GEE. Yes, sir.

Senator MALONE. Then would you tell the committee about the estimate of the supply of ilmenite or the raw material for titanium? Did not someone say that it was about the fourth most plentiful supply of metallic ores?

Mr. GEE. I think that is correct, Mr. Chairman. I think it is the fourth or fifth most abundant structural metal in the earth's crust. There is no question there are very large deposits. There is a scarcity of very high grade deposits. But in time of national emergency where cost is not a primary problem, undoubtedly we could supply ourselves.

Senator MALONE. Would you give the committee some idea of what the cost of raw materials means to the $5 per pound in sponge if you were in some kind of enlarged program of production? Isn't it a fact that it is a relatively small amount?

Mr. GEE. Yes, sir, it is a very small amount of the total cost. Ore would add only a few cents per pound to the titanium price.

Senator MALONE. Let us get this straight for the record. What is the percentage of ilmenite and iron metal in this ore that they are now working?

Mr. GEE. I am not certain as to the exact percentage, but it is my recollection that the ore body now being worked contains about 30 percent titanium dioxide.

Senator MALONE. Is that not a pretty high grade ore?

Mr. GEE. In terms of other metals, Mr. Chairman, that would be a very high grade ore. As you know, the average copper content of the ore mined in this country probably ranges about one-half of 1 percent.

Senator MALONE. They raised that a little in Nevada. They are up to about 1 or 1½ percent. Of course, you are out of copper ore until you want to break in a new deposit, so we just broke in a new one the other day, one of the largest in the country.

Mr. GEE. It is a problem of economics and low-grade ore can be used.

Senator MALONE. What does this 30-percent ilmenite run in iron?

Mr. GEE. I do not recall that percentage.

Senator MALONE. Approximately 50 percent.

Mr. GEE. Of the order of 40 or 50 percent iron oxide.

Senator MALONE. How low would you have to come, then, to make your supply plentiful?

Mr. GEE. I am not sure I understand your question.

Senator MALONE. Suppose you are working 50 percent iron and 30 percent ilmenite; that is a very profitable operation, is it not? What part of the cost and how would it increase the cost if you lowered it 10 percent? I am trying to get some idea for the committee, you see.

Mr. GEE. Yes, sir. Quite frankly I simply do not know the answer to that question. But I think in general terms, Mr. Chairman, the thing that we need is a greatly improved process far more than a better source of raw material. I think the first is much more important costwise.

Senator MALONE. I agree with you, but you have testified that you cannot get this from India at all in time of war, and it is problematical whether you can get it in time of peace; is that true?

Mr. GEE. That I think is what I said.

Senator MALONE. In other words, tomorrow if India wanted to be entirely neutral, in preparation for a war they could say that no more ilmenite will come to this country.

Mr. GEE. I assume so.

Senator MALONE. That being the case, you are afraid of that, so you are developing your own supply.

Mr. GEE. Yes, sir.

Senator MALONE. You say a few cents per pound in this raw material.

Mr. GEE. That is a gross approximation.

Senator MALONE. I am going to ask you to go into this in more detail for the committee, and do this in a brief with your men who know this material. I have never found the Du Pont Co. short of scientists and materials because they do not invest $9 million before they know something about it. The committee would like to know about it. We are not asking you to reveal any process. But if this few cents per pound in the raw material is important when you are in the 50 percent iron and 30 percent ilmenite, suppose you dropped to the percentage that makes it plentiful, then you might double that few cents and still not affect the $5 a pound.

Mr. GEE. It could well be.

Senator MALONE. Or $2½ per pound if you found a continuous process or electrolytic process that cut the price of the sponge. I would like to know right now what the percentage of the $5 a pound is in the

raw material for the benefit of the record. In other words, is not your experience or observation that new laboratory processes and experiments and laboratory results are generally satisfactory if you have a use where you make a profit on the material, like copper?

Mr. GEE. Yes, sir.

Senator MALONE. Would you not suppose that this production of ilmenite, 30 percent, would be a very, very, small percentage of any finished material, even if you got it down to $3.50 a pound?

Mr. GEE. I think so. The raw material cost of ore would be a small fraction of the total selling price.

Senator MALONE. We talked about power. I was going to ask you about the power you consume in kilowatt-hours per pound of sponge. It developed in the hearing in Henderson that from 16 to 22 or 23 kilowatt-hours per pound were consumed depending entirely upon the extent of the following through of the process was included in the estimate. Power at a cent a kilowatt-hour would be a maximum of 23 or 25 cents out of the $5. So it would not be too important unless you got it down to $1.50 a pound, when it would become important. Do you find it that way?

Mr. GEE. I think that is correct. The power consumption in titanium metal, like the ore raw material cost, is a small fraction of the overall cost.

Senator MALONE. So now you come back to the point you are making that the important thing right now is new and improved processes in order to lessen the cost of the material.

Mr. GEE. Yes, sir.

Senator MALONE. Your supply at the moment, and future potentials, are ample for your production.

Mr. GEE. Yes, sir.

Senator MALONE. And you have no hesitancy, or do you, in saying that no matter how much you might increase your production within the forseeable future, that you would get the raw material in this country if proper preparation were made?

Mr. GEE. In this country or Canada, I think that is probably correct.

Senator MALONE. Yes, I merely meant southern Canada, too.

General, do you have any questions that you would like to ask the witness?

General METZGER. No, sir.

Senator MALONE. We thank you very kindly for your statement, and if you will complete the record as indicated, we will appreciate it very much.

Mr. GEE. Yes, sir. (See letters, p. 347.)

Senator MALONE. I might say we consider your company outstanding in this field as of the present time and it may not be the last time we will call on you or some of your associates. So will you please hold yourself in readiness.

Mr. Bradford, of the Rem-Cru Corp.

Before we start with Mr. Bradford, Mr. Cullen of the Department of Commerce is here. Mr. Cullen, will you take a seat right here for just a moment?

Mr. Cullen, would you identify yourself for the record? We will complete your testimony later, but there is one question I want to ask you now.

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STATEMENT OF HERBERT L. CULLEN, MISCELLANEOUS METALS AND MINERALS DIVISION, BUSINESS AND DEFENSE SERVICES ADMINISTRATION, DEPARTMENT OF COMMERCE

Mr. CULLEN. My name is Herbert L. Cullen, Miscellaneous Metals and Minerals Division, Business and Defense Services Administration.

Senator MALONE. Mr. Cullen, you have heard the testimony on export of the titanium metal. Is it subject to permits for export?

LICENSING REQUIREMENTS OF TITANIUM EXPORTS

Mr. CULLEN. Yes, sir. At present it is necessary, first, for any order to be rated before one of the companies can accept it. That is, it has to have a defense rating. The usual method for obtaining such a rating is for the representative of the foreign country to go through the Foreign Operations Administration, who assist them in filing a request which clears through the Department of Defense.

Senator MALONE. You speak of a Foreign Exports Committee. Is that your committee?

Mr. CULLEN. No. I was speaking of the Foreign Operations Administration. That used to be ECA.

Senator MALONE. What is the Foreign Operations Administration now? What does it consist of?

Mr. CULLEN. You may be thinking, Senator, of the Export Control Policy Committee.

Senator MALONE. I am thinking of the committee you just mentioned.

Mr. CULLEN. The Foreign Operations Administration.

Senator MALONE. What is that?

Mr. CULLEN. That is the agency that used to be ECA.

Senator MALONE. What is ECA? That is the one that used to spend the money abroad?

Mr. CULLEN. Yes, sir.

Senator MALONE. You had to apply to ECA for clearance?

Mr. CULLEN. Yes. And ECA assists them in preparing a request which clears through the Department of Defense, the Office of the Assistant Secretary of Defense for Supply and Logistics. There is a priorities officer in that office. After his approval is secured, the request then comes to Business and Defense Services Administration, the priorities officer, Mr. W. J. Zepp, who actually issues the C–6 defense rating that is necessary before one of these orders can be accepted by the companies.

Senator MALONE. Then it comes to you for an export license?

Mr. CULLEN. No. I do not handle export licensing. I handle the scheduling of the mill products.

Senator MALONE. Does the Department of Commerce issue anything?

Mr. CULLEN. Yes. The Bureau of Foreign Commerce issues an export license.

Senator MALONE. In other words, it goes to this foreign control committee, which is made up of national defense principally, and clears through the national defense. After it is cleared there, then they come to you for a specific permit?

Mr. CULLEN. That is right.

Senator MALONE. And you are advised by this control committee how much can go to any certain country?

Mr. CULLEN. No.

Senator MALONE. You determine the amount?

Mr. CULLEN. That determination is made actually on the total amount that is actually delivered. The determination is made by the Department of Defense.

Senator MALONE. As to how much can be delivered, also?

Mr. CULLEN. It cannot be delivered—I am speaking of milled products—it cannot be delivered until after they are scheduled and rolled, and we do control the scheduling.

As a secondary check, we do require that the Bureau of Foreign Commerce clear the individual export licenses with us in order that we can check them against the schedules, to be sure that everything is in the clear.

Senator MALONE. You speak of "we" checking with the Department of Commerce. Are you not a part of the Department of Commerce?

Mr. CULLEN. Yes, sir.

Senator MALONE. Are you on this control committee, also?

Mr. CULLEN. No. There is no control committee, Senator.

Senator MALONE. What is it, again?

Mr. CULLEN. The Foreign Operations Administration.

Senator MALONE. Who are they? Just name them, please.

Mr. CULLEN. That is the Government agency that was originally ECA.

Senator MALONE. Who are they now?

Mr. CULLEN. It is a separate agency under Mr. Stassen.

Senator MALONE. That simplifies matters. It was Mutual Security; is that right?

Mr. CULLEN. It was Mutual Security last year.

Senator MALONE. What is it now?

Mr. CULLEN. Foreign Operations Administration.

Senator MALONE. Who are they, besides Stassen?

Mr. CULLEN. I imagine there are something like 1,200 employees over there now. There is a number of people.

Senator MALONE. Then if you wanted to export titanium, if Mr. Stassen says you can export, you can export; is that right?

Mr. CULLEN. No, sir, definitely not.

Senator MALONE. Tell us who has to pass on it.

Mr. CULLEN. They merely assist the foreign government in preparing a request for a rating. That rating request goes through the Department of Defense for approval. After it is approved there, the request comes to the Department of Commerce and the rating is granted by BDSA.

Senator MALONE. Who is it in the Department of Defense that actually passes on this material?

Mr. CULLEN. It is actually handled by Dr. Timothy C. May and Mr. Paul Haines, who is the priorities officer.

Senator MALONE. Mr. Stassen and his organization simply help the foreign country prepare the application to the Department of Defense, and that goes to Dr. Timothy C. May and Paul Haines?

Mr. CULLEN. That is right.

Senator MALONE. Do they pass on quantity as well as the fact that they may purchase it?

Mr. CULLEN. That is right.

Senator MALONE. After they have done their work, it then comes to you, and what do you do?

Mr. CULLEN. It comes to the office of Mr. W. J. Zepp, who handles the Priorities and Directives Division.

Senator MALONE. In the Department of Commerce?

Mr. CULLEN. That is right. He actually issues the C–6 military rating which permits these companies to actually get on an order board.

Senator MALONE. Is that a formality as far as Mr. Zepp is concerned, or may he turn it down?

Mr. CULLEN. It is a formality.

Senator MALONE. After the amount and permission has been granted by the Department of Defense, through Dr. Timothy C. May and Paul Haines, then it is simply a matter of a perfunctory operation that you issue the permit?

Mr. CULLEN. Yes.

Senator MALONE. But you do that in the amounts allocated?

Mr. CULLEN. Yes, sir.

Senator MALONE. Do you know the amount of titanium that has been exported, and to what countries?

Mr. CULLEN. I have the information for the third quarter and fourth quarter to date. There are two schedule B numbers. One represents raw material, and the other is the——

Senator MALONE. The raw metal would be the sponge?

Mr. CULLEN. And there are a lot of other alloys that they have classified in with this material.

Senator MALONE. What are those alloys?

Mr. CULLEN. I see one here, titanium copper alloy, 28 percent titanium; manganese nickel titanium alloy; and some silicon titanium, which runs only 44 percent titanium. Altogether, in the third and fourth quarter to date, we only have 1,437 pounds, and of that, I would say at least 1,400 pounds are these alloys, not pure titanium sponge.

Senator MALONE. Are not pure titanium metal?

Mr. CULLEN. That is right, sir.

Senator MALONE. Are there any other alloys besides the ones that you have mentioned?

Mr. CULLEN. It is difficult to say what the Bureau of the Census would classify in that particular schedule B number. It covers quite a range of hard materials.

Senator MALONE. Just read the nations to which the exports have been directed.

Mr. CULLEN. We have Japan, 1 pound; United Kingdom, 1 pound.

Senator MALONE. That is the first quarter of this year?

Mr. CULLEN. No, this is third and fourth quarter.

Senator MALONE. Of last year?

Mr. CULLEN. Of this year. These are approved licenses.

Senator MALONE. Not the actual shipments, but approved licenses.

Mr. CULLEN. United Kingdom, 1 pound, 28 percent alloy. United Kingdom, 15 pounds of sponge. Sweden, 220 pounds of manganese nickel titanium alloy. France 3 pounds of sponge. United King-

dom, .02 pounds, a very small test piece. Austria, 22 pounds of 20 percent titanium alloy.

Senator MALONE. What type of alloys?

Mr. CULLEN. It doesn't say.

Italy, 75 pounds of sponge and scrap. Belgium, 1,100 pounds of silico-titanium, 44 percent titanium.

On the wrought products, there is a total licensed of 22,900 pounds, of which all but about 14 pounds went to the United Kingdom.

Senator MALONE. Does that complete your list of the third and fourth quarters of this year?

Mr. CULLEN. Yes, sir.

Senator MALONE. Do you have any record of January to June, 1953, as to what you shipped to the various countries?

Mr. CULLEN. I have a copy of the table, which I understand the International Economic Analysis Division furnished to Mr. Adlerman. I would like to call your attention to the fact, Senator, that this table is rather misleading, because the Bureau of the Census has classified titanium slag in with the metal and alloys in crude form, so actually the figures are way off there.

Senator MALONE. Do you have any list there of ores and concentrates exported from January to June, 1953, of 1,778,681 pounds?

Mr. CULLEN. That is right, yes.

Senator MALONE. That is a little different than 1 pound and 2 pounds you have beeen exporting.

Mr. CULLEN. These are ores and concentrates.

Senator MALONE. Do you have any knowledge what the concentrates run?

Mr. CULLEN. I have no knowledge.

Senator MALONE. They do run up to 40 and 60 percent?

Mr. CULLEN. I would think so, yes.

Senator MALONE. Then there must have been a great change in the January to June, 1953, and the July to December, 1953, exports.

Mr. CULLEN. You understand, these are licensing figures I was just giving you. These are actual export figures. There are no licenses required for shipments to Canada.

Senator MALONE. How about to the United Kingdom?

Mr. CULLEN. Yes, sir.

Senator MALONE. What did you ship the United Kingdom in metals and alloys in crude form and in scrap, during that period January to June?

Mr. CULLEN. January to June shows a figure of 270 pounds of metal and alloys in crude form.

Senator MALONE. Belgium and Luxemburg?

Mr. CULLEN. 2,205 pounds.

Senator MALONE. That is right. We have the record, but it did not sound like the record you were reading, of 1 pound and 2 pounds and .02 pound.

Mr. CULLEN. I want to point out here that this figure of metal and alloys of crude form to Canada, 2,136,000 pounds, includes an indeterminate quantity of titanium slag. We do not know how much is metal. I suspect it is mostly slag.

Senator MALONE. It is in a form that any nation that knows how to handle it can use it?

Mr. CULLEN. If they have the plant and equipment necessary to produce sponge.

Senator MALONE. If they have brains to do it with; and the Germans had that, did they not?

Mr. CULLEN. Yes.

Senator MALONE. We presume that they are still in existence. Thank you. We will call you later to complete your testimony.

Mr. CULLEN. Yes, sir.

Senator MALONE. Mr. Bradford, would you identify yourself for the record, and if you have a prepared statement, you may proceed as you see fit.

STATEMENT OF C. I. BRADFORD, VICE PRESIDENT, REM-CRU TITANIUM, INC., MIDLAND, PA.

Mr. BRADFORD. My name is C. I. Bradford, vice President of Rem-Cru Titanium Corp., Midland, Pa.

Our company is jointly owned by Remington Arms Co., Inc. (a du Pont subsidiary) and the Crucible Steel Co. of America, and produces wrought titanium mill products. Its headquarters, including sales, research, melt shop, and general administrative offices, are located in Midland, Pa., not far from Pittsburgh. Rem-Cru does not produce metallic titanium sponge but purchases it principally from E. I. du Pont de Nemours & Co.

TITANIUM PRODUCTION

Rem-Cru operates its own melting department, utilizing furnaces of its own design to produce ingots of titanium and titanium-base alloys weighing up to 2 tons each. Processing of these ingots is done on Crucible's speciality steel mill facilities supplemented by others wherever required. Rem-Cru is supplying billets, bars, simple forgings, plate, tubing, wire, strip and sheet, in both commercially pure and alloyed titanium.

OUTLAY FOR RESEARCH

Rem-Cru was formed by Remington Arms Co., Inc., and the Crucible Steel Co. of America in August of 1950. The two companies united their know-how and manufacturing techniques, resulting from previous research and development work. Remington's investigations on titanium were initiated in early 1947, and this company was the first to announce its commercial interest in titanium and to make samples available for outside evaluation. Research and development have continued in Rem-Cru at a relatively high rate—$3,500,000 have been spent to date. Approximately 30 percent of Rem-Cru's present employees are technical and engineering graduates assigned to the further development of titanium.

Rem-Cru's production during 1953 has been limited only by the availability of sponge. Performance against forecast and promises to its customers can be illustrated as follows:

Period	Promises and forecasts	Shipments	Performance
	Pounds	*Pounds*	*Percent*
First quarter	195,000	153,952	78.9
Second quarter	241,400	266,445	110.4
Third quarter	297,000	260,570	87.7
October	100,000	115,897	115.9
Total	833,400	796,864	95.6

These shipments of good product represent average yields from sponge of 60 to 65 percent. A large percentage of the above product has been in the form of alloy sheet for such advanced planes as the F–100 and F–102 and in billet form for the J–73 jet engine.

Senator MALONE. May I ask you at that point, what becomes of the 30 to 35 percent? Is that scrap?

SCRAP

Mr. BRADFORD. About 15 percent of the remainder is nonrecoverable scrap lost in the form of pickling and grinding, and during melting. The remainder, as I will cover later on, is scrap.

Senator MALONE. It is a scrap metal, and you are now trying to make it available for further use?

Mr. BRADFORD. Yes.

Senator MALONE. It is not available now?

Mr. BRADFORD. That is right. I will cover that in just a moment.

Rem-Cru will produce and ship in 1953 between 500 and 600 tons of wrought titanium products. This is an increase over 1952 of fourfold. Melting production has reached a maximum of 125 tons in the month of October. This increase of over three-fold in the past year was made possible by supplementing the Du Pont supply with sponge from the Government rotating fund stockpile, small shipments from Japan, and the use of remelt scrap.

Rem-Cru considers the quality of its products of even greater importance than the quantities being produced. Quality control engineers applying statistical control methods have made it possible to improve all aspects of quality but, in particular, the uniformity of the material with respect to physical properties and mechanical condition.

Rem-Cru's facilities have been financed entirely by its two parent companies. No Government assistance has been obtained. Rem-Cru requires and has at its disposal for the rolling and fabricating of its products over $100 million of plant investment of the Crucible Steel Co. Rem-Cru's research and development program on alloys and melting has also been supported by the company, except for that sponsored by the Government, corresponding to less than 10 percent of the total.

GOVERNMENT RESEARCH PROJECT

Senator MALONE. How do you secure the Government's 10 percent?

Mr. BRADFORD. Through individual research and development contracts with the Ordnance Corps, the Navy and the Air Force.

Senator MALONE. In other words, they have some problem, and they assign it to you and pay the cost?

Mr. BRADFORD. That is right. And they receive the material as samples, and reports.

Senator MALONE. For that money?

Mr. BRADFORD. For that money, that is right.

Senator MALONE. Suppose you work out new processes and methods, are those processes and methods made available to the Government for other companies' operations, or are they patentable to you alone.

Mr. BRADFORD. Under these Government contracts, all information is made available to the Government, which in turn can be made available to the other companies in the business.

Senator MALONE. And used by the other companies?

Mr. BRADFORD. Yes, sir, for the Government's use.

As an example of the progress which is being made in the segment of the titanium industry in which Rem-Cru is interested, Rem-Cru has pioneered the following items:

(*a*) It developed the first titanium alloy sheet and is currently shipping 10 to 20 tons per month.

(*b*) It produced the first 2-ton ingot and several of these are currently being produced each week.

(*c*) It produced the first wide titanium strip on continuous hot and cold strip mill facilities. Several such strips are now being produced each month.

(*d*) It developed the first all-alpha alloy which is weldable and which possesses improved high-temperature properties. Production is just now being undertaken on this new alloy.

UTILIZATION OF SCRAP

Rem-Cru has recognized from the beginning that the supply of titanium metal could be extended and the cost of wrought products reduced through efficient utilization of scrap titanium metal from its own and its customers' operations. Accordingly, the scrap remelt problem has been attacked along several lines in order to permit the reuse of the maximum quantity of material at the earliest possible time. Methods have been developed for reducing trimmings, turnings, and sheared ends to sufficiently small particle size so that it can be fed with the titanium sponge into our conventional melting furnaces.

Senator MALONE. For that part of the scrap you are reusing it?

Mr. BRADFORD. To the extent mentioned in the next sentence. As a result, the use of such scrap has averaged approximately 10,000 pounds per month for the last 6 months, or 5 to 10 percent of the ingot tons produced. During this period, approximately 15,000 pounds of titanium turnings have been purchased from customers and scrap dealers and have been used. The company's net accumulation of potentially usable scrap is about 10 percent of its total purchases of sponge—150 tons of scrap.

Senator MALONE. To determine what the loss is, for the record, there is 35 to 40 percent in scrap, and you are using, I understand you to say, 10 percent of such scrap?

Mr. BRADFORD. Yes.

Senator MALONE. That would cut it down to 25 to 30 percent?

Mr. BRADFORD. Of which 15 percent is nonrecoverable.

Senator MALONE. Why do you say that?

Mr. BRADFORD. It is lost in grinding and in pickling.

Senator MALONE. Yes. The 10 to 15 percent is lost for any use.

Mr. BRADFORD. That is right.

Senator MALONE. But you now are using 10 percent of that approximately 20 percent?

Mr. BRADFORD. Yes.

Senator MALONE. How much of the additional do you think can finally be made available for reuse?

Mr. BRADFORD. As I will mention in a moment, we are working on methods which we think will make it all available.

Senator MALONE. Thank you. At the moment, that is one of the real problems in the industry, is it not?

Mr. BRADFORD. Absolutely.

Senator MALONE. And one of the real items of cost?

Mr. BRADFORD. Yes, sir.

Development work on additional means of utilizing scrap is continuing along the following lines:

(*a*) Means of consolidating massive scrap so that it can be used as consumable electrodes in conventional cold mold furnaces.

(*b*) Rem-Cru has under development a new type of melting procedure which will permit the direct utilization of all types of scrap. This new type of furnace will also permit the production of higher quality ingots.

It is the policy of Rem-Cru to provide melting and fabricating capacity equal to or greater than its available sponge supply. Accordingly, additional melting facilities are now under construction which will raise our average melting capacity to 10 to 12 tons per day during the first half of 1954.

We are planning to expand beyond this rate as required. Studies are under way to determine the facilities needed to handle the metal which might be available under the present sponge production expansion program. It is likely that certain existing steel-mill facilities must be supplemented in order to handle efficiently the tonnages of titanium to be produced during the next 5 years. Our studies will point up these requirements well in advance.

Rem-Cru is very much aware of the importance of titanium to the defense effort and has made a major contribution to the establishment of the titanium industry. It is currently devoting its efforts to performing a sound, quality-conscious job and simultaneously planning for continuing healthy growth during the years ahead.

Senator MALONE. Does that complete your statement?

Mr. BRADFORD. Yes, sir.

Senator MALONE. What is your estimate of the civilian use, if all the sponge that was necessary were available?

Mr. BRADFORD. As has been mentioned earlier today, it has been difficult to make any accurate appraisal of the civilian market. It is a function, as you know, of two things. The obvious one is cost, and the other one is the development time which will be required for new users to obtain experimental quantities, try them out, and put them into effect. So, I regret, Mr. Chairman, I am not able to give

you any estimate that I think is of any value as to what the civilian market is.

Senator MALONE. In terms of what we are now producing—and you heard the evidence this morning that it is probably much less than 10 tons per day of sponge, maybe 7½ tons—would you say that there is a civilian use far greater than that amount being produced?

Mr. BRADFORD. Depending on price. At the present price, I would be doubtful.

Senator MALONE. Are you familiar with the production of commercial planes?

Mr. BRADFORD. Yes.

Senator MALONE. Do you know that the testimony shows that commercial planes could use titanium to a large extent even now if they knew it were available, and could take the plans off the drafting board? Do you know that has been the testimony of the companies in the commercial and war production of planes?

Mr. BRADFORD. I was not aware of it.

Senator MALONE. Even at the present time.

TITANIUM REQUIREMENTS

Mr. BRADFORD. When I said because of the way the DC–7 job was being handled, I was lumping commercial airlines into my statement about present markets at present prices would exclude commercial airlines.

Senator MALONE. We are not discussing warplanes, because that would be decided by the national defense of the Nation.

Mr. BRADFORD. That is right.

Senator MALONE. We have already had testimony that even in that field we need 10 or 15 times as much as we are now producing if we knew it would be available at a quality that could be readily used.

You presented some very fine testimony as to the progress that is being made in its efficient use. Are you aware that testimony has been presented that a tremendous amount of this material could be used in warplane construction?

Mr. BRADFORD. Only generally. I have not had access to figures.

Senator MALONE. And you do not include commercial planes in your statement?

Mr. BRADFORD. I was including commercial planes with the military.

Senator MALONE. Apparently you are not aware of the demand at the present time. When I say that, I wish you would tell me if you are, because the testimony is quite contradictory to your statement that at the present price you might not need any more.

Mr. BRADFORD. I am sorry I confused your point. When you asked me the question about present markets for titanium as related to present supply, and I said I doubted if the civilian market could absorb it, my answer was based on other than aircraft.

Senator MALONE. That is considerably different.

Mr. BRADFORD. Yes. I am very sorry.

Senator MALONE. Then we will assume that the companies manufacturing commercial and warplanes know what they are talking about. You would assume they would know what they are talking about, would you not?

Mr. BRADFORD. Yes, indeed.

Senator MALONE. In other commercial uses, what did you have in mind? Would you give us some idea of your experiments or investigations in other than aircraft?

Mr. BRADFORD. We have carried on a very limited laboratory research program because of the limited availability of metal. We have not been in a position to put samples in the field. But we have carried on work in the laboratory on chemically corrosion-resistant alloys that might be suitable for the petroleum industry. We believe intuitively that in the long future, if the price is reduced, there are markets for such alloys in the petroleum and chemical industries.

Senator MALONE. It is, then, more corrosion-resistant than any other metal?

CORROSION-RESISTANT QUALITIES

Mr. BRADFORD. Depending on conditions and the alloy.

Senator MALONE. You think there would be a tremendous market in the chemical and petroleum fiields?

Mr. BRADFORD. That is right.

Senator MALONE. If it were available?

Mr. BRADFORD. And the price were right.

Senator MALONE. What is the price now for your rolled sheets?

Mr. BRADFORD. Sheets are currently selling for $18 to $22 a pound, depending on quality and size. Billets and bars are in the range of $10 to $12 a pound.

Senator MALONE. Are you able to readily supply the demand with what you are getting in sponge?

Mr. BRADFORD. Our acceptance of orders and delivery is based on the availability of sponge. At the present time, and all through 1953, we could have sold more metal if we had had more sponge available.

Senator MALONE. That was the statement I was interested in. In other words, your markets are obviously beyond your supply.

Mr. BRADFORD. Yes, sir.

Senator MALONE. How much of this material that you describe as alpha alloy can you produce?

Mr. BRADFORD. Immediately it would be in the range, I presume, of 10 to 25 percent. I hesitate there a little bit.

Senator MALONE. Of the sponge material that you secure, that much could be made into that quality?

Mr. BRADFORD. Yes. I qualify it that way only because of ignorance as a result of just starting production.

Senator MALONE. You, yourself, have all of the information that your company has?

Mr. BRADFORD. Yes.

Senator MALONE. And you are right in the middle of your experiments?

Mr. BRADFORD. Yes.

Senator MALONE. At least you are just starting production.

Mr. BRADFORD. That is right.

Senator MALONE. Would you say from your experience or your observations in other metals, that as long as the demand is greater than your production, that the production could be increased?

Mr. BRADFORD. Yes, sir.

Senator MALONE. Profitably even at the present price?

Mr. BRADFORD. Yes.

Senator MALONE. What quality of sponge is required for this alpha-grade alloy?

Mr. BRADFORD. About the same quality of sponge as we are using and have been getting from our suppliers for our other products. Our specification is 180 Brinell maximum, and we have used up to 200, and occasionally a little above 200.

Senator MALONE. If the material is uniform to the Government specifications, then you could use any of it?

Mr. BRADFORD. Yes.

Senator MALONE. It has not yet reached the uniformity that is necessary, so you have to be selective, is that it?

Mr. BRADFORD. No. When I remarked that our production of the all-alpha new type alloy would be somewhat limited, that answer had to do with the inherent problems of scaling up any new alloy such as this type, and some of the rollability problems associated with this material. It is not limited by the availability or the quality of the sponge.

ROLLING EQUIPMENT

Senator MALONE. Maybe you have answered the question I was about to ask. Have you made any estimate of the demand for your alpha alloy material in the event it was unlimited in the foreseeable future?

Mr. BRADFORD. No, we have not.

Senator MALONE. It would be greater, however, than you are now manufacturing?

Mr. BRADFORD. Yes.

Senator MALONE. Quite a considerable amount?

Mr. BRADFORD. We are talking of an indefinite, long-term future. Yes, we would be very much disappointed if it were not much greater.

Senator MALONE. The reason we are asking you is because you are the expert. The committee wants your opinion because your opinion, as long as you are in the middle of these problems of experiments, would be very valuable to us. Do you have special rolling mills for this material, or do you use the regular steel rolling machinery?

Mr. BRADFORD. We are using the regular—by that, I mean specialty stainless steel type of rolling equipment which Crucible has available for its standard product, with minor modifications and supplemental items.

Senator MALONE. There is some testimony—and we did not follow through too much because all of this is to determine the extent of the demand for the material—that when the demand was great enough and the production of sponge was great enough to justify special rolling equipment, that it might turn out a more uniform material and there might be less waste in the production. Have you made any studies along that line?

Mr. BRADFORD. We are studying the general subject constantly, and I would agree with the general thoughts you have expressed. It has been found in aluminum and stainless steel that equipment designed especially for those metals will produce higher quality with more efficiency and higher yields.

Senator MALONE. We had some very interesting information from some of the producing companies in the aircraft industry. Of course, we consider Mr. Douglas one of the outstanding men in this field. He testified that on a particular airplane, the DC–7, they could save at the present moment about 200 pounds by the use of titanium, and they estimate that each pound saved in a commercial aircraft is worth about $40, which would indicate that cost would not be a limiting factor, then. Have you any information in this regard?

Mr. BRADFORD. We have had, since the beginning of our titanium work, that problem with the aircraft manufacturers, because, as you imply, it has an intimate bearing on the markets. We have had some difficulty in getting a consistent answer on how much a pound of weight saved in an aircraft is worth. We have had figures as low as $15, and as high as $200.

Senator MALONE. We purposely went to see Mr. Douglas and several others in Los Angeles for that reason. At $200 a pound, the savings on that airplane would be about $8,000. This would be by no means the ultimate saving. This is just what you have available now. It has been indicated several times that if they had the titanium that was needed so they could take the plans off the drafting board and use the titanium for the airplanes, it would result in a 30 percent additional payload.

I am not in the airplane business, but they say that is quite an objective.

As I understand it from your general testimony, you are in the business because you think it has future possibilities.

Mr. BRADFORD. I have staked my future on it.

Senator MALONE. Those are the kind of men who really go someplace. Then with your company organized and operating particularly in this field, the whole future of your company and all of the personnel does depend upon the future of this metal.

Mr. BRADFORD. Yes, sir.

Senator MALONE. Then I take it, without your really answering the question, that you believe this metal has a tremendous future if the volume can be increased and the cost correspondingly reduced?

Mr. BRADFORD. Absolutely. Our company was founded on that basis, that it would develop into a high-tonnage material in the next 10 to 20 years.

Senator MALONE. In other words, you are getting into this material at about the same place that somebody got into the aluminum production when aluminum cost $40 to $50 a pound. There are quite a few people now who are making considerable money and making a good living out of the business.

Mr. BRADFORD. Yes.

Senator MALONE. I believe that is all.

Do you have any questions, General?

General METZGER. No.

Mr. BRADFORD. I have some pictures which I would like to submit for the record.

Senator MALONE. This is a set of four pictures illustrating points in your testimony. They will be received as exhibit No. 1

(The pictures referred to were marked "Exhibit No. 1" and are in the files of the committee.)

Senator MALONE. Thank you very much. I may say it is very gratifying to know that there are companies in this business because they think there is a future in it.

You have heard the testimony today. You know the objectives of the committee. If you and your associates have any further information, you may submit either a brief or letter, to the chairman or any member of the committee. We would be very happy to have the information.

Mr. BRADFORD. Thank you very much.

Senator MALONE. We will recess at this time until 2 o'clock this afternoon.

(Whereupon, at 12:35 p. m., a recess was taken until 2 p. m., of the same day.)

AFTER RECESS

Senator MALONE. The committee will be in order.

Colonel Mesick of Army Ordnance. Colonel, you were here this morning, and you heard the objectives of the committee, which, I will say again, are not to find chinks in the armor, but are to determine how best the committee can be helpful to the national defense, and to the economic structure of this country.

You are familiar with Resolution 143 of the Senate, which directs the committee to determine the availability of these materials to the United States in wartime, and for our expanding economy and security.

STATEMENTS OF COL. BENJAMIN S. MESICK, COMMANDING OFFICER, WATERTOWN ARSENAL, MASS., AND E. L. HOLLADAY, RESEARCH AND DEVELOPMENT

Colonel MESICK. Yes, sir.

Senator MALONE. You are spending your life in the area of national defense and the security of this country. There are about 77 of these materials but today we are holding a hearing on titanium, this metal that is reported to have twice the strength with the same weight as aluminum, practically noncorrosive, and some other classified advantages.

Testimony so far from the airplane companies and other users, both actual and potential, has shown a very much larger demand than we have under contract for production.

I called you because you are in Army Ordnance. Army Ordnance has an established reputation and has always had outstanding men as have the Navy and the Air Force. I would like to know from you what position you think this metal ought to play in the national defense.

If you have a statement, you may read it, or comment from it and submit it for the record. Will you identify yourself for the purpose of the record and proceed in your own way?

Colonel MESICK. Col. Benjamin S. Mesick, Ordnance Corps, commanding officer, Watertown Arsenal, Mass.

I am very glad to make a verbal statement, Mr. Chairman. I did not know until I arrived home from Canada yesterday, of this hearing, so I had no chance to make a prepared statement.

Senator MALONE. I want to say now that we will probably have some questions to ask you after your verbal statement, and if you would like

to round out your statement in any way through a brief or any supplemental information, you are welcome to do it.

Colonel MESICK. And submit it later?

Senator MALONE. Yes.

MILITARY USES FOR TITANIUM

Colonel MESICK. I perhaps would like to do that, sir.

In connection with the titanium program, the Ordnance Corps and the Department of Army recognized from the first its great potential value to our type of equipment, that is, to give a specific example, if we make a medium tank which weighs out of steel 28 tons at the present time, we make that out of titanium alloy, it will weight somewhat less than 20 tons. So it is obvious to nonmilitary people, as well as to military, that this would be a tremendous advantage over a potential enemy from the standpoint of air transportability and from the standpoint of mobility on the ground where with the same powerplant you can get a great deal better performance out of your automotive vehicle.

However, recognizing that the amount of metal which would be available for development work would be very limited, the Chief of Staff of the Army at that time, Gen. J. Lawton Collins, set up three priorities. The first was anything that was to be handled or carried by the infantry soldier, because General Collins stated that he knew from his own experience in New Guinea and other places how vital it was to save even a pound or two off what our doughboy had to carry.

Senator MALONE. I expect, Colonel, even officers served in another capacity than officers.

Colonel MESICK. Yes, sir.

Senator MALONE. I remember in the first war we had a 75-pound pack, and also a 35-pound pack, and in many cases the officers ended up with both the 75 and the 35. I think even a pound would help a man at 3 o'clock in the morning when he was going somewhere.

Colonel MESICK. I know from personal experience the same as you do. So therefore one of our first applications as most of the people I think in this room know was the mortar base plate, in which we were able to reduce the weight of the integrated base plate for the 81 millimeter mortar from approximately 50 pounds down to 22½ pounds.

You might say why not make that out of aluminum. Aluminum is half as heavy as the titanium. However, aluminum has a different stiffness, so that to make the same thing out of aluminum as has been done in Canada, it weighs even more than the titanium to do the same job. We save one man there which can be made up by either carrying more ammunition and also less chance of someone being killed. That was the first application.

Then we have gone on to many things in that first category, such as the grenade launcher, the bayonet, the entrenchment tools, the helmet and you can name everything that pertains to the individual soldier. A few ounces here and a few ounces there adds up.

Now, we go to the second priority. The second priority is combat weapons, both artillery and automotive vehicles, so they can be air transported.

Senator MALONE. Before you leave the soldier, is there any move to use titanium in small weapons?

Colonel MESICK. Yes, sir. I do not want to be specific for reasons of security.

Senator MALONE. I want you to understand, Colonel, if any question might require an answer which includes classified information, you say so, and if it becomes necessary for the committee to have the answer, we will have an executive session or personal interview.

Colonel MESICK. Yes, sir. There are certain weapons that are carried, particularly by pilots in aircraft and so forth, which have been made out of titanium at a good saving in weight.

Senator MALONE. Do you find the efficiency holds up comparably?

Colonel MESICK. Yes, sir. Just on the experimental, making one or two at a time, they are very, very expensive. However, we have developed the know-how so they could be produced in quantity if the material was available.

Senator MALONE. Is there any reason after there is a stabilization of quality and quantity, and the weapons are ordered in quantity, that there should be any material increase in price?

Colonel MESICK. There would not be because of the research that has already been done in machineability, hot and cold working and so forth. The characteristics are very similar to alloy steel with which industry is familiar.

In the combat vehicles and heavy artillery we have gone ahead and used approximately 50 or 60 tons a year of titanium metal for the purposes of building purely prototypes for test by the service board, that is, by the artillery and infantry, and so forth. We have not gone into the third category, which is the very heavy artillery, and the very heavy tanks, and so forth, which would not be transported by air. Those are in the lowest priority, and there is not metal enough available at the present to go into those.

Senator MALONE. But even if they are not transported by air, they are transported overland, and it seems to me I remember some of that heavy field artillery broke up a lot of roads in different places in the First World War.

Colonel MESICK. Yes, sir.

Senator MALONE. There would be great advantage if they had the material.

Colonel MESICK. There would be great advantage if the material was available at an economic price. So far as we can go in our development work, we are getting all of the experience and all of the know-how we can.

Senator MALONE. Could we not amend that statement to this extent, that if the material could be made available and it resulted in a saving of lives by getting the material there on time, regardless of the condition of roads and that sort of thing, even the price might not be too great a factor?

Colonel MESICK. I agree.

Senator MALONE. As long as we are financing the world anyhow.

Colonel MESICK. That is right; yes, sir. Then the only other part as far as the overall aspect is concerned, we have recognized from the beginning that with the Air Force, as the chairman said this morning, it is imperative as you found out from your hearing in Los Angeles, that the Air Force have titanium for their airframe manufacture, and also for jet engine manufacture.

Senator MALONE. Someone said something like this at one time, that there is no second best poker hand. Does not that sort of conform to a second best air squadron, in fact?

Colonel MESICK. If they were unable to have the metal; yes, sir.

Senator MALONE. It is second best, no matter what metal, if they cannot fly as fast as the enemy and do not have better maneuverability than the enemy aircraft. You do not want second best air power.

Colonel MESICK. It will never win again.

Senator MALONE. There is no second best, then.

Colonel MESICK. That is right. Our consumption at the present time in the Department of Army averages between 50 and 60 tons a year, which is very small compared to the requirements of the Air Force. However, whenever it is available, we are definitely interested in having it and using it in our equipment.

Senator MALONE. Colonel, could you either now or in a supplemental statement give us an idea of the amount of this material that might be used or usable in your department if we could just assume that the metal would be available and at a price that the national defense organization would authorize? Could you give us some estimates of the tonnage?

Colonel MESICK. The only thing I can use as a broad overall picture is the amount of alloy steel which was used during World War II by Ordnance. The total amount of steel used by Ordnance was something like 12 million tons a year, and of that, I would say that around 6 or 8 million tons would be about equivalent to the type of material we used. However, I want to make clear that there would not be any idea of replacing all of that. There is no question of replacing alloy steel or aluminum or magnesium. It is just another asset in our national basket. So I would give a figure, if there was plenty of it available, that we would certainly use around a million tons a year.

Senator MALONE. To start off with.

Colonel MESICK. For everything.

Senator MALONE. Now, let us explore that just a little bit further. If the several pounds that you would save on the foot soldier could be saved, and you had all the material you needed for use in all the small arms and the material that goes into an airplane there would be a great saving in transportation cost and an increase in efficiency, would it not?

Colonel MESICK. Yes, sir.

Senator MALONE. It takes aircraft, ships, railroads, and roads to transport an efficient army. If you had the material available, and assuming that the Defense Department and Congress agreed to appropriate the money you would not be building any new material out of anything else where titanium could be used as a more efficient substitute.

Colonel MESICK. No.

Senator MALONE. In other words, you would use up what you have until you got enough to replace it.

Colonel MESICK. Certainly we would do that.

Senator MALONE. You have testified now that titanium could be used in small arms and ordinary size artillery so you are satisfied that this metal can be alloyed so that it will take place of the steel alloys.

Colonel MESICK. We have investigated certain alloys, I will put it that way. We have not anywhere near completed all of them.

Senator MALONE. I did not mean that. You have gone far enough so that you know it will take over if you got the material.

Colonel MESICK. There may be others that will do it better. Perhaps the alloys we have been working with so far are not the best alloys. We do not know.

Senator MALONE. That is right. But you have tested enough alloys now so that you know that, as far as you have gone it will stand up.

Colonel MESICK. Yes, sir.

Senator MALONE. So it is just a question then of price and availability.

Colonel MESICK. Yes, sir.

Senator MALONE. Thank you. Go right ahead.

Colonel MESICK. I do not believe there is anything that I could add to the picture, Senator, other than that broad statement. If there is any particular phase of it, I would be glad to answer any questions I can.

Senator MALONE. What are those alloy materials running in percentage of titanium generally speaking.

Colonel MESICK. Most of them are at least 92 percent titanium. The other 7 or 8 percent is made up of normal alloying elements, such as chromium, magnesium, aluminum, and so forth.

Senator MALONE. It does not vary much from steel?

Colonel MESICK. That is right. That is why we at the Watertown Arsenal have been given the responsibility for the titanium, because of our experience with steel.

Senator MALONE. I happened to be consultant to the Senate Military Affairs Committee during World War II, and I inspected the arsenal. You had chromite steel in your 30.06 rifle.

Colonel MESICK. Yes, sir.

Senator MALONE. Somebody conceived the idea that you ought to cut down the chromite in this steel because it was scarce. I happened to know you could get it if you wanted to get it, so we made a little different arrangement when we came back. There was something about a certain number of shots that it took to deform the chromite steel barrel, and if you did not use the right amount of chromite a lesser number of shots would cause the deformity. I forget the details. Is that correct?

Colonel MESICK. Yes, sir; that took place about 1931 and 1932.

Senator MALONE. We went through the Watertown Arsenal and that is one thing we hit upon. Somebody in the War Department, no doubt of a very fine school, who had not shot a rifle, sent the order. But we fixed that up. We are in that business right now, and we must depend on men like you. You have an associate, Mr. Holladay. You are together. Do you want to supplement the statement?

Mr. HOLLADAY. I could add nothing to what Colonel Mesick said. We have been working on this program for about 3½ years.

Senator MALONE. Are you at the arsenal?

Mr. HOLLADAY. No, I am in Washingon and handling this end of it.

Senator MALONE. You are available here?

Mr. HOLLADAY. Yes.

Senator MALONE. I think you made a very valuable contribution, Colonel, because as I understand it, you say you could use a million to a million and a quarter tons of alloys if you never looked back, but went right ahead into production.

Colonel MESICK. I want to bring out, Senator, that is purely very long range. That would be doing in a matter of 10 or 15 years what it took the steel industry 30 years to do.

Senator MALONE. You are only in one angle of it. You are not in the production business.

Colonel MESICK. No, sir. We use only wrought material that we purchase from the producers.

Senator MALONE. I am asking you to assume the material available. If it was available tomorrow, you could take these plans off the board.

Colonel MESICK. Absolutely.

Senator MALONE. We will talk to some other people about making it available. Your contribution is very valuable. You say it could be used, if you had it.

Colonel MESICK. Yes, sir.

Senator MALONE. When we started into this hearing we could not give all the 77 strategic minerals and fuels the same attention we are giving this. On a top priority basis, we held hearings on the production of uranium materials in this country, as well as these hearings on titanium, and the testimony is rather convincing—that if we gave our domestic producers one-tenth of the tax break that we give the foreign producers, you probably would not need to go out of the country for titanium ore in about 3 to 5 years.

We found out that producer after producer of considerable size would have to stop mining their deposits after 3, 4, or 8 months work in a year because they would go into another tax bracket and make no money at all on their investment. So we did not ask them what they were going to use the uranium ore for. We find that out back here. The Commission knows that. We want to be able to make proper recommendations to the Senate on what in our opinion could be done to help you.

Colonel MESICK. Yes, sir.

Senator MALONE. I think there are plenty of people who want to produce titanium metal. We will know more about it at the end of tomorrow. You have made a very valuable contribution. A million tons of titanium is a lot of titanium as of today. Maybe tomorrow, speaking in years, it might not be very much. There are some people who think they have it whipped now.

Colonel MESICK. Yes, I know.

Senator MALONE. Does that complete your statement?

Colonel MESICK. Yes, sir.

Senator MALONE. I want to thank you very much, Colonel, and you, Mr. Holladay. I have been in the engineering business, not in your business. I only knew enough that when I heard about some theoretical fellow down here cutting off an ingredient that fixed up a rifle so it would fire several thousand more shots than otherwise, he did not know what he was talking about. Thank you very kindly.

If you find you would like to make any further statement after you get home, you fix up a little brief and mail it to the chairman at the Senate Office Building. Thank you.

Colonel MESICK. Thank you, sir.

(The information referred to follows:)

DEPARTMENT OF THE ARMY,
OFFICE OF THE DEPARTMENT COUNSELOR,
Washington, December 14, 1953.

Hon. GEORGE W. MALONE,
Chairman, Subcommittee on Minerals, Materials and Fuels Economics Committee on Interior and Insular Affairs.

DEAR MR. CHAIRMAN: Transmitted herewith is a statement by Col. Benjamin S. Mesick, Army Ordnance Corps, Department of Army Coordinator for Titanium, giving the Army's views on titanium, which is submitted in amplification of Colonel Mesick's presentation before the subcommittee on November 23, 1953, and in response to your request. If further information is needed, this office will be pleased to assist you in obtaining it.

Sincerely yours,

JOHN G. ADAMS, *Department Counselor.*

STATEMENT BY COL. BENJAMIN S. MESICK, ORDNANCE CORPS, DEPARTMENT OF ARMY COORDINATOR FOR TITANIUM

This statement is in amplification of the oral presentation made at that time, and is submitted at the request of the chairman of the subcommittee, Senator George W. Malone.

1. The advantages to be obtained by the use of titanium and its alloys in fighting equipment used by the Army have been recognized by the engineers responsible for the development of such equipment from the time that the characteristics and physical properties of this metal became known. The Ordnance Corps has the responsibility within the Department of the Army for the investigation of all metals having potential application in Army equipment whether to be developed by Ordnance or by one of the other technical services. For that reason Ordnance began its investigation of titanium as soon as the first commercial production of the metal was carried out by the du Pont Co. in 1948. Available funds for this program were limited, but sufficient design data were obtained to justify an official recommendation by the Ordnance Corps to the Chief of Staff, United States Army, to exploit to the maximum extent the applications of titanium in Army equipment. It should be noted that these recommendations were made in June 1950, but prior to the opening of hostilities in Korea.

2. The unfavorable characteristics of titanium should be noted along with the characteristics which make it highly desirable for use in Army equipment. The melting point of titanium is considerably higher than that of steel, and at those elevated temperatures it has a great affinity for gases such as oxygen and nitrogen which compose air. For that reason, melting, casting, or welding of titanium must either be done in a vacuum or in an inert atmosphere of helium or argon. Normal refractory materials, moreover, will not withstand the high melting temperatures of titanium, so that either water-cooled copper molds or graphite crucibles are currently being used for casting the molten metal and absorption of carbon in the latter case makes the resulting material unusable for many applications. The other adverse characteristic of titanium is its susceptibility to erosion and galling, but research has developed surface treatments which tend to overcome this adverse characteristic.

3. It was the opinion of the Ordnance Corps, however, that the advantages to be gained from the high strength, low density characteristics of titanium more than outweighed the adverse characteristics for many applications in Army equipment and particularly in Ordnance items such as combat vehicles and appropriate components of artillery. The results of experiments between 1948 and 1950 indicated that by replacing selected components now made of alloy steel by titanium alloys of equal strength that savings as high as 40 percent in weight could be achieved. It was realized, however, that further development of the titanium industry would be necessary before the maximum savings in weight could be obtained, but even in 1950 savings of 25 percent could be assured assuming that the current problems of fabricating the wrought metal into the finished end items would be mastered, which has been the case.

4. On August 10, 1950, the then Chief of Staff, Gen. J. Lawton Collins, designated Col. Benjamin S. Mesick, Ordnance Corps, to represent the Department of Army in working with industry in developing the production of titanium by experimental application of titanium in any item of Army equipment where the responsible designers believed that a significant saving in weight could be realized. At that time titanium metal was being produced at an annual rate of about 100 tons, and only about 50 tons were actually produced in the calendar year 1950. Recognizing that the Navy and Air Force had great interest in the use of this new engineering material, the available supply of titanium necessitated the establishment of priorities for experimental application, and such priorities of necessity had to be headed by items requiring only pounds of the metal as compared to the tons which would be needed for such an item as a medium tank. The Chief of Staff, therefore, established priorities which are still in effect for the Department of Army:

(*a*) Any item which is carried or handled by the individual soldier. While savings of only a few ounces may be achieved on any one individual item such as the bayonet or grenade launcher, the sum total of all metallic items could conceivably amount to several pounds and each pound saved is a tremendous factor in its effect on the individual soldier and his fighting capabilities. Much greater savings have been obtained by the redesign of such items as the 81 millimeter mortar base plate and outriggers for antiaircraft artillery, which are carried or handled by men. In the case of the former, the complete base plate of titanium is in 1 piece weighing 22½ pounds as compared to the standard steel base plate which consists of 2 pieces each weighing 25 pounds, and requiring 2 men in the mortar squad instead of 1 with the titanium plate. Because of the lower modulus of elasticity of aluminum and magnesium, a one-piece mortar base plate of those metals actually weighs more than the base plate made of titanium.

(*b*) Equipment which is designed for air transportability. It is obvious that every ton, or even every hundred pounds of cargo weight that can be saved on an item to be transported by air means payload available for other cargo such as ammunition or men; or increased range for the same amount of fuel consumed by the transport plane. At the same time, in the case of a combat vehicle, the savings in weight would give increased mobility in combat on the ground. For example, it is quite feasible to expect at some future time to be able to fabricate appropriate components of a tank out of titanium that would have equal fighting capabilities to a present 28-ton tank, but would weigh only 20 tons or less. Similar advantages are apparent and practical in the fabrication of artillery such as the 155-millimeter gun. It should be noted, however, that decreased weight is not desirable in all components of an artillery piece because of the relation between mass and recoil energy.

(*c*) Heavy items of equipment for which air transportation is not contemplated. In such items the tonnage of titanium required would be large and the increased mobility on the ground to be obtained would be a definite advantage over a future enemy. These advantages are obvious, and need not be discussed.

5. For the execution of this directive from the Chief of Staff, the Ordnance Corps selected Watertown Arsenal, Mass., which installation is recognized as the titanium development center for the Department of Army. The first step taken was to formulate a comprehensive program of Research and Development to include both basic and applied aspects of the problem. Watertown Arsenal and the Office, Chief of Ordnance, were assisted and advised in this program by a Metallurgical Advisory Committee representing both Government and private agencies concerned with titanium as an engineering metal. This same committee has served as the medium of exchange of information between the armed services in regard to technical information and use of titanium, and the Navy and Air Force have contributed greatly to the success of the program by their wholehearted cooperation. The Metallurgical Advisory Committee on Titanium was formed in September 1950, and since that date has reviewed and advised in the expenditure of over $10 million of Government funds. It has been the impetus provided by this program that has enabled the titanium industry to demonstrate its tremendous value to national defense and in progress in 3 years to a degree without precedent in metallurgical history.

6. It has been the consistent policy of the Army to refrain from sponsoring research which has as its primary purpose the extraction or winning of the metal from its ore, whether it be molybdenum, chromium, titanium, or any other metal. The accomplishment of such objectives is considered to be more properly the responsibility of some other Government agency outside the

Department of Defense such as the Bureau of Mines. In the case of titanium, moreover, private industry stated a preference for carrying out their own research in extractive metallurgy so that proprietary rights could be protected, and the record shows that millions of dollars have been and are being spent to develop a process that will produce metal of a satisfactory quality with considerably less cost than by the current magnesium reduction process. To meet the Army requirement for high-quality titanium sponge for certain Ordnance applications, the construction of facilities at the Bureau of Mines Experimental Station at Boulder City, Nev., was financed by the Army at a cost of over $1 million. In addition to providing the sponge to meet a critical need of Ordnance, this plant is now producing about 25 tons per month of sponge which is allocated by the Office of Defense Mobilization to augment the limited production by private industry.

7. The production of titanium from all sources has increased termendously as compared to the total production of about 50 tons of sponge during 1950, but the anticipated production rate of 7,500 tons per year by the end of 1953 is not likely to be achieved. Latest reports indicate that the total production for the calendar year 1953 will be less than 3,000 tons. Prospects are better for the calendar year 1954, but great expansion of production must take place by 1956 if the stated needs of the Air Force alone are to be met. As a result, the Army and the Navy must limit their consumption of wrought titanium to experimental applications only so as a result the requirements by Army will be limited to 50 to 60 tons per year. It can be stated, however, that under the condition of unlimited availability of titanium and assuming that price were of no concern, the Department of Army could advantageously use 1 million tons of titanium per year at some future time if necessary development engineering will have been completed and if it was a period of all-out rearmament in a national emergency.

Senator MALONE. Mr. Garrett, executive director of Materials Committee, Office of the Assistant Secretary of Defense for Research and Development, and Mr. Nathaniel Fick, director of Panel on Metals and Minerals, Office of the Assistant Secretary of Defense for Research and Development.

Mr. Garrett, you are with the Research Department of the National Defense Department.

STATEMENTS OF JOHN H. GARRETT, EXECUTIVE DIRECTOR OF METALS COMMITTEE, OFFICE OF ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND DEVELOPMENT; AND MATT FICK, DIRECTOR OF PANEL ON METALS AND MINERALS, OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND DEVELOPMENT, WASHINGTON, D. C.

Mr. GARRETT. Office of the Assistant Secretary of Defense.

Senator MALONE. You are Assistant Secretary of Defense?

Mr. GARRETT. No; with the office.

Senator MALONE. With the Office of Assistant Secretary of Defense. Who is the Assistant Secretary?

Mr. GARRETT. Donald A. Quarles.

Senator MALONE. Mr. Garrett, you were here this morning?

Mr. GARRETT. Yes, sir.

Senator MALONE. You are familiar with the objectives of the committee, so if you will identify yourself for the record, you may proceed to make any statement you care. If you have a prepared statement you may make it a part of the record or read it.

Mr. GARRETT. I am John H. Garrett, executive director of the Committee on Materials of the Office of the Assistant Secretary of Defense for Research and Development. I am here representing the Assistant Secretary, Mr. Donald A. Quarles. I can only comment

with regard to the research and development aspects of the problems of the Department of Defense, and not for the Secretary of Defense as a whole.

USE OF TITANIUM TO INCREASE EFFECTIVENESS OF WEAPONS AND EQUIPMENT

Since titanium will in many instances contribute to increased military effectiveness of weapons and equipment——

Senator MALONE. Right at that point, you are able to testify through your research what titanium as a metal will do?

Mr. GARRETT. Yes, sir.

Senator MALONE. You look to the Assistant Secretary and the Secretary of Defense for your orders as to what it will be used for?

Mr. GARRETT. We also are interested in applications of titanium. The whole field of research and development, including developing improved military equipment, is within our responsibility.

Senator MALONE. To make this a little clearer, you determine where it can be efficiently used. As to whether or not it would be used, that would be up to the Secretary of Defense. You are in the field of determining what it will do in certain fields, and where it will be advantageous in your opinion to use it?

Mr. GARRETT. I think I could clarify that a little more. I am part of a staff of the Secretary of Defense, and within his staff is the Assistant Secretary for Research and Development, Mr. Quarles. He is responsible for design of all equipment. He does not look to any other branch of the Office of Secretary of Defense.

Senator MALONE. He does determine what it is going to be used for, based on its availability and efficiency.

Mr. GARRETT. That is within his responsibility.

Senator MALONE. Go right ahead.

Mr. GARRETT. It is our policy to encourage measures that will lead to the adoption of titanium wherever improved performance will justify its cost. To the extent that titanium can replace materials containing critical alloying elements, which would be in short supply under war conditions, the use of titanium will contribute to conservation objectives which are always under active consideration.

It is our belief that development of specific production processes and process controls should be left largely to industry. We know that industry is putting out a great effort. It is our belief that the problem of variable production quantity can only be solved through the experience that will come with increased production.

For this reason we are encouraging the support of production to the highest practical level through active coordination with the Office of Assistant Secretary of Defense for Supply and Logistics and the GSA. We are supporting a program of fundamental research on the extractive metallury of titanium.

Results of this work will benefit all producers of titanium but work of this nature could not be individually supported by company research efforts.

RESEARCH BY DEPARTMENT OF DEFENSE

The Department of Defense research program has in the past devoted considerable effort to determination of phase diagrams to alloy

development, and to studies of fabrication methods. We are gradually withdrawing from these fields, leaving most of this to industry to pick up, and are shifting emphasis to broader experimental application of titanium in military items as production expands and metal becomes more available. It is easy to become very enthusiastic about titanium. We are trying to be careful not to oversell the metal. The metal has definite and inherent shortcomings stemming from its crystal structure, and its affinity for impurities. It will also be expensive to produce and difficult to fabricate. For this reason its civilian market will in all probability be limited for several years to come.

Some of the military applications for which high hopes are held now might also turn out to be impracticable. There will always be competition among materials and there are indications that the growing competition from titanium is causing both the steel and aluminum industries to increase their efforts to develop improved alloys and attempt to narrow the area where these earlier materials will be dispaced by titanium.

Nevertheless, we feel sure that there will be numerous applications where titanium will improve the military performance of material to the extent that it will attain an important place in our catalog of materials.

The Office of Secretary of Defense has sponsored a number of studies during the past 2 or 3 years in order to satisfy ourselves that the titanium program is on the rails, and that everything possible is being done to make titanium widely available for military equipment. The first of these studies was made in 1951 at our request by the Minerals and Metals Advisory Board of the National Research Council, which surveyed the status of the research and development program, estimated the probable extent of useful applications of titanium and made recommendations for Department of Defense action. Partly as a result of this report an extensive program of fundamental research on extractive metallurgy was undertaken under the administrative control of the Office of Naval Research. We have relied so heavily on titanium in designing our military equipment of the future that we wanted to be sure the metal would be forthcoming when needed.

A study made by a group of civilian expert consultants to our office reviewed the progress being made by industry in improving extraction processes and increasing production. This information was made available to the Defense Materials Procurement Agency, who directed their program accordingly.

A second study is being made for us at the present time by the Minerals and Metals Advisory Board of the National Research Council to determine whether or not the current research and development program on titanium is in balance with engineering needs of military items under development.

In 1950 we sponsored a symposium in order to bring together producers, potential users, and Government people to stimulate research in this new area of interest to the military. The Army, Navy, and Air Force are each conducting an active program of research and development on the aspects of titanium which are of particular interest in their respective applications. There are representatives here from

each of those Departments who are able to discuss the details of their research and development programs, if you would care to go into it, so it will not be necessary for me to go any further into that.

That is the extent of the statement that I have prepared. I would be glad to answer any questions that I can.

Mr. ADLERMAN. You say you have had reports made to you by the Minerals and Metals Advisory Board, and also by some civilian experts. Do you have those reports available?

Mr. GARRETT. We do have them. They are classified.

Mr. ADLERMAN. Are any to be declassified and submitted to the committee for use in its records?

Mr. GARRETT. Any parts that could be declassified?

Mr. ADLERMAN. Yes. Could you submit the classified records for the study of the committee, with the idea that the classification would be respected.

Mr. GARRETT. We can certainly do that.

Senator MALONE. Mr. Garrett, we are interested, of course, in two things; first, the quality of the material you are receiving, the amount, what you are now doing, which I think you have explained, and what you would do and how much of this metal you think you could use if it were available so that you did not have to worry about the availability of it any more than you do aluminum or steel.

QUALITY AND QUANTITY OF TITANIUM REQUIRED FOR DEFENSE

Mr. GARRETT. First, with respect to the quality of the metal, up until recently that has been one of the major concerns for the users of the metal, that the quality has been extremely variable from one batch to the other. We have had numerous and lengthy discussions in our office as to what could be done to alleviate this situation. The conclusion was reached that really the only thing that could help would be to increase production, to give the producers the experience they need in processing the metal to enable them to make it time after time with the same quality. That is one of the major considerations in our recommending increased production of the metal, to permit the producers to gain experience in process control.

With respect to quantity, our own office is not itself responsible for quantity figures. We are, of course, interested in making sure that when titanium is widely specified in designs of military equipment, and that equipment is released for production, that the titanium will be available when it is needed. From that point of view we have been quite concerned in seeing how the production was coming along.

About a year and a half ago we made the recommendation through the then Munitions Board to DMPA, that production be increased to 35,000 tons per year within 3 years from then, which would be a year and a half from now. We were informed that those would be the requirements that could then be foreseen for titanium from the services, and we wanted to make sure it was available as needed, and also we thought the quality of themetal itself wold be improved if production was built up to some such figure as that. We therefore made that recommendation.

Senator MALONE. I am glad you mentioned the 35,000 tons. I have been wondering where that figure came from. I did understand

it was 36,000 that was recommended and that the national-defense organization recommended 22,000.

Mr. GARRETT. We recommended 35,000 a year and a half ago.

Senator MALONE. It did not go through?

Mr. GARRETT. That went to—they change the agencies quite a bit.

Senator MALONE. Just enough so no one knows who is doing it.

Mr. GARRETT. At any rate, it is the agency that the Office of Defense Mobilization has taken under its wing now.

Senator MALONE. Who is that?

Mr. GARRETT. It was DMPA that was responsible for the actual procurement.

Senator MALONE. Who is responsible now?

PROCUREMENT RESPONSIBILITIES

Mr. GARRETT. The Office of Defense Mobilization is responsible now.

Senator MALONE. That is Dr. Flemming?

Mr. GARRETT. Yes. That organization reduced our recommendation from 35,000 tons to 22,000 tons that became the official goal that they were trying to meet by encouraging various companies to increase their production to that figure.

Senator MALONE. You heard the testimony this morning that production is now about 6 or 6½ tons a day, maybe a couple of thousand tons a year being manufactured. Do you know what the total tonnage under contract would be when full production is achieved?

Mr. GARRETT. I believe it is in the neighborhood of fourteen to sixteen thousand tons a year.

Senator MALONE. It is 13,500, I think. Two companies each have a 10-ton contract. It was explained this morning by Du Pont that its present production is 2½ tons and it took a 7½-ton increase. But both Titanium Corp. of America and Du Pont Co. combined now produce about 6½ tons a day or less. Part of that is going to England and some other nations. It was testified some went to Austria. I guess they have some agreement that it would not go to Russia. National Defense, as I understand, O. K.'d the exports. Do you know anything about that?

Mr. GARRETT. No, sir. This is the Office of Supply and Logistics, Dr. May. We know him, of course, and work with him, but we are not ouselves responsible for approving those requests and do not see them, and are not familiar with them.

Senator MALONE. You are not familiar with who is responsible for teaching Russia how to make it? The committee is very much interested in your department, because you are the research department upon which the National Defense Chiefs depend, for the practicality of the use of this metal, and whether it will do a certain job or not. Is that right?

Mr. GARRETT. I might say about that that the actual research is administered by the departments. Our job is to coordinate it. We do not ourselves conduct or administer any research programs.

Senator MALONE. You do have men in your department who understand the research and are in close touch with it?

Mr. GARRETT. We try to keep in touch with it as closely as a small staff permits.

Senator MALONE. Do you have some one on your small staff who is equipped by training so as to know what he is doing?

Mr. GARRETT. Mr. Fick and I between us try to keep in close touch with what is going on with the metal.

Senator MALONE. You understand the research and understand how the research is done, so you have what is going on?

Mr. GARRETT. Yes, sir.

Senator MALONE. Then if you recommend to the National Defense Chiefs that this metal is good for a certain use, you have every reason to suppose that they will include it in specifications?

Mr. GARRETT. It is not done exactly that way.

Senator MALONE. Give use an idea how it operates.

Mr. GARRETT. The specific applications of the metal are selected by the people in charge of the various designing programs within the military departments. We have here today and I think they will testify later the people who are in charge of titanium development for each department.

Senator MALONE. What do you mean titanium development?

Mr. GARRETT. I mean the research and development programs that are administered by each department on titanium.

Senator MALONE. Do I understand you to say that there is more than one research department?

Mr. GARRETT. By department, I mean the Army, Navy, and Air Force.

Senator MALONE. They have three research departments?

Mr. GARRETT. They have each of their own, and each have their several bureaus and services, and then they in turn each have their own program.

Senator MALONE. You know I was under the impression we consolidated them in 1947 or 1948.

Mr. GARRETT. That is what we try to do. We try to take these dozen or 15 different agencies that are each running a research program.

RESEARCH PROJECTS—MILITARY

Senator MALONE. Would you for the benefit of the record name some of these research organizations and who engineers the deal?

Mr. GARRETT. I will be glad to. In the Army we have the Ordnance Department. Mr. Holladay, who testified a moment ago, who is in charge of the Materials Section for the Army Ordnance.

There is Army Quartermaster, which has a research department. The Engineer Corps have a research program. The Chemical Corps has a smaller one. The Signal Corps has a research and development program.

In the Navy there is the Bureau of Aeronautics, the Bureau of Ordnance, Bureau of Ships, Bureau of Naval Research, all four of them are interested in titanium.

In the Air Force, of course, it is Wright Field that directly conducts the research program and there are two main laboratories at Wright Field, the Materials Laboratory and the Aeronautical Laboratory, that both have extensive programs in titanium.

Senator MALONE. You are conducting a research center for all this?

Mr. GARRETT. We endeavor merely to coordinate, to get them to

sit down around the table and talk over their problems so each knows what the others do. The budget requests for research and development all come through our office, and we try to see that moneys are allocated fairly among them.

TITANIUM REQUIREMENTS

Senator MALONE. Then you are responsible for the 22,000-ton recommendation.

Mr. GARRETT. The 35,000 tons is what we recommended.

Senator MALONE. You felt that was what was needed?

Mr. GARRETT. This was based on the figures the Departments gave to us. The way we got the figure, we went to the then Munitions Board, and the Board went to the Departments and said, "How much will you need 3 years from now" and they added up the figures, and they came to 35,000 tons.

Senator MALONE. When you go to the Navy you go to their research department?

Mr. GARRETT. No, sir, because the Munitions Board are the people who compile the figures.

Senator MALONE. Who are they?

Mr. GARRETT. Under the new Department of Defense reorganization they were discontinued on July 1.

Senator MALONE. Who does that now?

Mr. GARRETT. Supply and Logistics, Office of the Assistant Secretary of Defense.

Senator MALONE. You are working for the man you now describe?

Mr. GARRETT. No, we are Research and Development. We are another Assistant Secretary of Defense.

Senator MALONE. Who is the Assistant Secretary of Defense responsible for the amount of titanium?

Mr. GARRETT. Supply and Logistics. His name is Mr. Thomas.

The Munitions Board shortly before it became defunct last spring sent us a new estimate of titanium requirements.

Senator MALONE. What was that estimate?

Mr. GARRETT. That was 35,000 tons per year. They raised it from thirty to thirty-five thousand a year later. It can be expected, of course, as time goes on and more applications are proved, that the rquirements will gradually grow.

Senator MALONE. Over what period did they think you would need 35,000 tons a year?

Mr. GARRETT. I believe again that was 3 years. I know our original estimate was 3 years from then which would be only a year and a half from now.

Senator MALONE. Their recommendation was that you would need 35,000 tons a year for the ensuing 3 years beginning last year?

Mr. GARRETT. 35,000 tons a year after 3 years. In other words, it would build up to 35,000.

Senator MALONE. It would take 3 years to build up to 35,000?

Mr. GARRETT. Yes.

Senator MALONE. I would say that is getting closer.

Mr. GARRETT. I should say one more thing about these estimates, that all of them are based on the current price of titanium, and if

the price comes down substantially, the requirements would be very much higher.

Senator MALONE. Even though someone else built some planes out of titanium, you would not get very far?

Mr. GARRETT. As far as airplanes go, I think price was considered not to be a factor. But when you get to ships or tank armor or something that would make an individual piece cost many millions of dollars more, then you have to stop and consider price.

Senator MALONE. This 35,000 tons included the Air Force, Navy, and Army?

Mr. GARRETT. Yes, sir.

Senator MALONE. You would not reach that for 3 years?

Mr. GARRETT. Our original 35,000-ton figure which is the one I am more familiar with was 95 percent roughly Air Force requirement and 5 percent Navy aeronautics requirement. The land and sea requirements were at that time infinitesimal. They were very small. What they were were just for experimental applications and not for production.

Senator MALONE. Might I ask you whom you called in the Air Force to get this amount that the Air Force might use over the ensuing 3 years to build up to their part of the 35,000 tons annually.

Mr. GARRETT. We went to the Munitions Board, and their sources of information I don't know. But they have regular contacts in the Department that are responsible for furnishing them requirements information.

Senator MALONE. You could furnish that for the benefit of the record, that is, who is responsible for the 35,000?

Mr. GARRETT. I will certainly try to find out for you. Many of them are gone that were there a year and a half ago, and there might be some doubt among those left who they did contact.

(See letter from Roger Lewis, Assistant Secretary of the Air Force, to chairman, December 15, 1953, and letter from W. N. Lawrence, Director, Military and Atomic Energy Division, Defense Production Administration, to Nathaniel Knowles, Jr., Vice Chairman for Materials, Munitions Board, pp. 585, 586, and 606.)

Senator MALONE. I would say offhand that would be an improvement if most of them are gone. Are you familiar with the later estimates of what the Air Force would need now if titanium were available and they could take the planes off the drafting board and be able to depend on the supply in the same way they now depend on aluminum and steel?

Mr. GARRETT. No, sir; I am not, except for the testimony I heard this morning.

Senator MALONE. That same testimony is available to you and your department.

Mr. GARRETT. We very much want it. We have already made contacts with your staff to see how soon we can get the testimony.

Senator MALONE. You can have your copy right away. You can take it home with you. I would like to have you back tomorrow after you read it. I will tell you for your benefit the testimony has been somewhere around 100,000 tons a year at the present price or at any price. I do not think you are going very far in trying to economize on lives, because it is a little expensive. What do you think about it?

Mr. GARRETT. We have never felt that price was a factor for aircraft applications. I judge that this is all aircraft, this 100,000 tons or essentially so?

Senator MALONE. You heard the testimony a few moments ago from the ordnance man, that ordnance could use a million tons a year of this material if they could use it in the packs that the servicemen carry and in your relatively small caliber guns.

Mr. GARRETT. Ordnance has indicated that at the current price they would not be interested in any appreciable amount of titanium.

Senator MALONE. I did not hear him say that. We will call them back again.

Mr. GARRETT. I think he would say that.

Senator MALONE. If he does, we will have him in your category.

Mr. GARRETT. We depend entirely on what the Departments tell us for their requirements. We do not estimate the requirements ourselves.

Senator MALONE. Do you take what they tell you?

Mr. GARRETT. We are forced to.

Senator MALONE. Then evidently you did not take this from their testimony unless they have changed considerably.

Mr. GARRETT. They have changed it. We got our requirements from them about a year and a half ago, and at that time they said it was 35,000 tons.

Senator MALONE. Altogether?

Mr. GARRETT. We are currently engaged in another study of it, and we do not yet have the new figures.

Senator MALONE. How do you conduct one of these studies? Does it take a year or two to get the information together?

Mr. GARRETT. We make our studies through a body of experts.

Senator MALONE. Who are they?

CONSULTANTS AND ADVISORY BOARDS

Mr. GARRETT. Largely the National Research Council, Metals and Minerals Advisory Board.

Senator MALONE. Who are they?

Mr. GARRETT. They have a permanent committee of about 16 outstanding metallurgists of the country.

Senator MALONE. Of the whole country?

Mr. GARRETT. Yes. Then they have panels of consultants in addition. I think they have about 400 names.

Senator MALONE. It must take quite a little time when they get through with all of those.

Mr. GARRETT. They do not go through all those. When a specific problem comes up, they select from those 400 the individuals that are particularly well qualified to make that study. It takes them a few months to make a thorough study.

Senator MALONE. Would those names be available to the committee?

Mr. GARRETT. Yes.

Senator MALONE. I would like to have the 400 and check off the ones you think are the experts in titanium use.

Mr. GARRETT. I would be glad to.

Senator MALONE. You can make it a part of the record of your testimony.

Mr. GARRETT. We have one of their detailed reports here that has the name of their panel listed, and I can read the names off, if you care to have me.

Senator MALONE. Read a couple of paragraphs from the report that might be significant.

Mr. GARRETT. The Metallurgical Advisory Board itself at this time which was nearly 2 years ago, and I think there have been a few changes, but it is essentially the same as it was here.

Senator MALONE. Nobody dies or resigns?

Mr. GARRETT. The chairman has changed. At this time Dr. R. F. Mehl of Carnegie Tech was chairman. At the present time Dr. Francis Frary, formerly director of research of Aluminum Co. of America, but now retired, is chairman.

He is retired. He has no present commercial connections of any sort. Dr. Mehl is vice chairman. Dr. Jeffries is the other vice chairman. The members are Dr. E. C. Bane.

Senator MALONE. Who is he?

Mr. GARRETT. He is director of research and vice president of United States Steel.

I will submit the list for the record.

Senator MALONE. Submit the list as a part of your testimony.

Mr. GARRETT. Yes.

The members of the Titanium Panel are as follows:

Dr. Bruce W. Gonser, Battelle Memorial Institute.
Mr. C. I. Bradford, Rem-Cru Titanium, Inc.
Mr. E. H. Bunce, New Jersey Zinc Co.
Dr. H. P. Croft, Kennecott Copper Co.
Dr. E. A. Gee, E. I. du Pont de Nemours Co.
Mr. S. A. Herres, Titanium Metals Co. of America.
Dr. I. R. Kramer, Horizons Titanium, Inc.
Mr. E. I. Larson, P. R. Mallory & Co.
Mr. David Swann, Union Carbide and Carbon.
Dr. Eugene Wainer, Horizons, Inc.
Mr. V. W. Whitmer, Republic Steel Co.
Mr. N. A. Ziegler, Crane Co.
Mr. F. J. Cservenyak, Bureau of Mines.
Dr. R. C. Dalzell, Atomic Energy Commission.

Senator MALONE. Let me ask you, What is the nature of the question that you submit to these men? They are very acceptable men. There is no question about that. Did you ask them what amount of metal could be made available at certain times, or did you ask them how much they thought you should use in aircraft and other materials, or just what was the nature of your inquiry?

RESPONSIBILITIES AND OBJECTIVES

Mr GARRETT. No, sir. I will be glad to enter into the record a copy of our letter of assignment to them, because it is all done in writing.

Senator MALONE Do you have it with you?

Mr. GARRETT. No, but I will get it.

Senator MALONE. Could you describe it?

Mr. GARRETT. It says generally that we would like to make a survey of the current titanium research and development program of the three military departments to ascertain whether or not the program as it is now constituted fully meets the engineering requirements of the new military designs that are being developed for improved equipment.

Senator MALONE. How would they know about the new military designs? Do they go to the aircraft companies to find out what can be done with titanium if they had it?

Mr. GARRETT. Many of those people are from the titanium companies and they know that just from their ordinary business; from their daily work they know that, or should know it.

Senator MALONE. There would be room for question there because we have plenty of testimony from the aircraft companies that the production is not even approaching what they need.

Mr. GARRETT. This study, Senator, is not directed at production, because we ourselves who have asked for the study are not concerned with production except indirectly.

Senator MALONE. You are talking about the need.

Mr. GARRETT. The need technically speaking, but not quantitatively speaking. We in research and development are only indirectly interested in quantity. We are directly interested in whether, for example, the titanium alloys being developed are the best than can be developed to meet the needs of airplanes, for example.

Senator MALONE. Do you know the best alloys that are now available? Did you ask them a question whether those alloys are available and in what amounts or what you need of the alloys now available, or how efficient they would be in replacement of other materials?

Mr. GARRETT. Yes, indeed.

Senator MALONE. What did they tell you?

Mr. GARRETT. We do not have the report yet. They are just making the study.

Senator MALONE. How long have they been on it?

Mr. GARRETT. We gave them an assignment in June, as I recall it.

Senator MALONE. When do you expect to have the report?

Mr. GARRETT. Some time this winter.

Senator MALONE. At least it will be early next year?

Mr. GARRETT. Yes, sir.

Senator MALONE. When you get this report, do you suppose it will show any increase in the availability of these materials? You merely ask them if the present alloys would take the place in efficient use. Did you ask them that?

Mr. GARRETT. What we asked them was more or less the statement I made before.

Senator MALONE. I do not understand it yet.

Mr. GARRETT. It was a rather general statement directed at whether the research and development program is adequate in scope and balance to meet the needs of the situation.

Senator MALONE. Let us find out what you do mean. What you are asking them is if the research now being conducted in the Air, Navy and Army is efficient and covers the field, and should be continued. Is that what you are asking them?

Mr. GARRETT. No, sir, we are not asking them to look into the competence of the administration of the program at all. We are asking if the objectives of the program are well suited to the needs.

Senator MALONE. What are the objectives of your program?

Mr. GARRETT. We would like to make sure that the departments are trying out experimentally titanium in every useful application or every application which it looks as though it will contribute to the performance of the equipment.

Senator MALONE. Let us see where you are getting on this. We already have testimony before this committee that they could use 100,000 tons of this titanium if you had it in the kind of alloys you now have, and at the present price. You are going back to a committee to find out if they know what they are talking about in this research, is that it?

Mr. GARRETT. It is not tied in at all with quantity.

Senator MALONE. In other words, you are afraid that these alloys that they are now capable of producing will not do the work in taking the place of aluminum and the steel that they are using now, is that it?

Mr. GARRETT. That is one aspect of it. We are afraid that the current commercial alloys are not quite good enough. We think we want something better.

Senator MALONE. No doubt you would want something better. But we have already had testimony that, if you will give them the specifications and that is your business, they can produce these alloys, and we have testimony they could use something like 50 times what you are now producing.

Mr. GARRETT. This is one of the objectives of this study, to make sure that the Departments are applying the existing alloys where they can be used.

Senator MALONE. I think that is a wonderful study, but it has nothing to do with the quantity.

Mr. GARRETT. No, sir.

Senator MALONE. What are you doing on that score?

Mr. GARRETT. My office has nothing to do with quantity.

Senator MALONE. We have the wrong men here.

Mr. GARRETT. You may have the wrong man. I tried to explain that when I started the testimony, and also when Mr. Adlerman called me, that I could speak only of the research and development program, but that anything to do with quantity figures was the responsibility of the Supply and Logistics.

Senator MALONE. You are in the National Defense; do you have at your fingertips what the Navy is doing, what the Air Force is doing, and what the Army is doing, and you coordinate all this?

Mr. GARRETT. We try to do it.

Senator MALONE. What is the Air Force doing?

Mr. GARRETT. I would a lot rather, sir, that you get that from the Air Force.

Senator MALONE. I already got it from the Air Force, but I want to know what you know about it, as long as you are supposed to know.

Mr. GARRETT. I would like to say this, that the titanium program is only a small fraction of the entire program that we try to keep in touch with.

Senator MALONE. Then in other words, you do not know very much about the titanium program.

Mr. GARRETT. I will say this——

Senator MALONE. You are not making it any kind of specialty. You are taking it as a group of experiments run by the Army, Navy and Air Force, without any special attention to titanium at all.

Mr. GARRETT. I would not say that at all. I would say that titanium is one of 3 or 4 of the things we have devoted particular attention to.

Senator MALONE. What is the Air Force doing right now at the moment? What do they need?

Mr. GARRETT. Our information is that the Air Force research and development program on titanium out of research and development funds runs about $400,000 a year.

Senator MALONE. I do not think we are very interested in the cost. What do they say about these alloys? Will they take the place of some of these other metals and to what extent?

SPECIAL PROPERTIES OF TITANIUM

Mr. GARRETT. They definitely will, and they range from 250° Fahrenheit up to perhaps 700° or a little higher with the present alloys, and titanium looks as if it will take the place of either aluminum or steel. We have hopes that we can push that upward temperature limit up to 1,000° or so.

Senator MALONE. If you know that, what is the sonic temperature when you pass the sonic barrier?

Mr. GARRETT. The temperature does not rise very much at the speed of sound.

Senator MALONE. What is it?

Mr. GARRETT. I do not carry those figures in my head. At the speed of sound it is only some 15 degrees. But it goes up rather rapidly above that. At twice the speed of sound, just pulling a figure from my head, I believe the temperature rises around 250° Fahrenheit.

Senator MALONE. At what speed does aluminum become impractical?

Mr. GARRETT. I am sorry. I misspoke myself. At twelve or thirteen hundred miles an hour, which is considerably less than twice the speed of sound, it is around 200° to 250° Fahrenheit.

Senator MALONE. Where do you leave the aluminum?

Mr. GARRETT. Just about at that temperature. About 250°, or about twelve or thirteen hundred miles an hour, we start to get out of the range where aluminum will stand up.

I should also say that it is not entirely the heating due to speed that we have to worry about. In our fighter planes the engine is in the fuselage and the fuselage structure around the engine is subject to heat that comes from burning of fuel in the engine.

Senator MALONE. We are talking about the plane itself. We will go into the engine later. If you want to go into the engine now, you may.

Mr. GARRETT. I meant to talk about the structure of the plane around the engine which will be heated perhaps 200° or 300° above the air temperature.

Senator MALONE. What is the temperature where it is not practical to use aluminum?

Mr. GARRETT. About 250°.

Senator MALONE. In other words, when you get up into the supersonic speeds, you have to start looking for a new metal.

Mr. GARRETT. That is right.

Senator MALONE. That being the case—I am not going to ask you how fast your planes can fly, that will be another department, I suppose—is it not necessary to add this lighter material in order to gain your maximum speed for any type of plane?

Mr. GARRETT. It is very desirable to have it. It fills the gap between aluminum and steel.

Senator MALONE. Then you can either take up that saving in weight, with additional fuel, or it can go faster and can carry a heavier load. There are many ways.

Mr. GARRETT. Those things are true.

Senator MALONE. If you can do that and we have had testimony along the lines that you are testifying now, you still think that 35,000 tons is all that you are going to use the next 3 years annually if you had it?

Mr. GARRETT. This is the figure that the departments gave us. I have no way of checking on them.

Senator MALONE. Have you checked with the departments recently?

Mr. GARRETT. I personally have not.

Senator MALONE. I should say it would be a good idea.

Mr. GARRETT. As I say, the quantitative figures are not anything that we are primarily concerned with in my particular office.

Senator MALONE. Let us leave it in your field. You do know that this metal takes over when you have to leave aluminum.

Mr. GARRETT. Yes, sir.

Senator MALONE. And it will go up to what temperature?

Mr. GARRETT. About 700°.

Senator MALONE. What speed would you reach that temperature?

Mr. GARRETT. That would be in the neighborhood of Mach 2.

Senator MALONE. Where is that?

Mr. GARRETT. Fifteen or sixteen hundred, depending on the altitude.

Senator MALONE. Did I not read in the paper the other day that someone rode in these missile planes at 1,200 miles an hour?

Mr. GARRETT. We have experimental planes that have flown that fast.

Senator MALONE. Is not one of the duties of your department to keep ahead of any potential enemy in the production of this craft?

Mr. GARRETT. We are certainly trying to do that. As I say, titanium is one of the major efforts in research and development.

Senator MALONE. Is it not necessary, as a matter of fact?

Mr. GARRETT. It is.

Senator MALONE. Do you think that 35,000 tons are going to even touch it?

Mr. GARRETT. I have no opinion on that because I have no way of having an opinion on the quantity.

Senator MALONE. Your department after hearing from the Air Force and the Navy and the Army set 35,000 tons as the amount needed at the end of 3 years?

Mr. GARRETT. The Office of the Secretary of Defense did, yes, sir, but I cannot speak for the whole office. I can only speak for the research and development part of it.

Senator MALONE. That was in 1952.

Mr. GARRETT. In 1952, we recommended 35,000 tons.

Senator MALONE. Who was your Secretary of Defense then?

Mr. GARRETT. Mr. Lovett.

Senator MALONE. He is responsible then for setting the 35,000 tons.

Mr. GARRETT. The 35,000 tons was set, I believe, this spring under Mr. Wilson.

Senator MALONE. He raised it.

Mr. GARRETT. 5,000; this was based on new figures received from the departments.

Senator MALONE. You did not wait on this committee you have now asked to make a new report.

Mr. GARRETT. This committee will not have anything to do with the quantitative requirements.

Senator MALONE. Anybody can figure the quantity needed if he knows the number of planes and type after he knew you could use it. Could not any engineer do that? If you determine what is to be done, then somebody ought to know the number of planes and different sizes. You know the parts that would be replaced. Then you could get a man on one of these computing machines and figure out the amount you need.

Mr. GARRETT. That is the way it is done, but it necessarily has to be done by those departments who are responsible for the individual designs. For example, one of our current airplanes is designed with something like 700 parts in titanium. To find out the weight of titanium in that airplane you have to sit down and add up 700 parts.

Senator MALONE. Is that much of a job?

Mr. GARRETT. To get that done for the whole Department of Defense, you have to get the people with the information, and those people are down in the individual departments. So if we need a total figure, what we do is to go back to the individual departments.

Senator MALONE. Is that your job?

Mr. GARRETT. I do not have that job.

Senator MALONE. Who has that?

Mr. GARRETT. That is the Assistant Secretary for Supply and Logistics, Mr. Thomas, and Dr. Tim May, whose name was mentioned specifically in charge of the titanium effort in the Supply and Logistics office.

Senator MALONE. Do you not suppose that the manufacturers of the planes have a pretty good idea?

Mr. GARRETT. I am sure they do.

Senator MALONE. Will you read their testimony?

Mr. GARRETT. I very much want to read it.

Senator MALONE. Then we would like to have you back.

Mr. GARRETT. Yes.

Senator MALONE. Will you be back tomorrow?

Mr. GARRETT. Yes, sir; I expect to.

Senator MALONE. Mr. Hitchcock of Boeing testified that we are going to produce a billion pounds of airframe weight—we are talking about a war now. I do not know whether you fellows contemplate one or not, but according to every paper we pick up, we are just about to get in a war. In 1956 we probably will require about 200,000 tons of sponge. If we were going to do that in 1959 or 1960, if we had suitable alloys, forging sheet, extrusions that number could very well be 400,000 tons.

This is only one of your manufacturers. I do not expect he understands it well. But I would go to him after I consulted this civilian

committee to at least find out what he has to say. That does not consider commercial planes, and I think you heard this morning about the value they claim when they save a pound in weight. I do not know about that. All I know is the testimony. When I asked Mr. Hitchcock the question, he said each pound of weight saved is worth anywhere from $20 to $1,000 a pound. You can choose any number you wish. Everyone you talk to will quote a different number.

As far as a commercial airplane is concerned, I would guess that each pound of weight saved would amount to $40 a pound.

There is considerable testimony in there that is enlightening to me, but probably would not be to you. When you save a pound of weight, you also save a lot of other things.

Mr. GARRETT. I think you save 7 or 8 pounds to 1.

Senator MALONE. So we will call you tomorrow afternoon.

Mr. GARRETT. I would like to make one other suggestion if I could, if I come back tomorrow and you still want testimony on quantitative figures, I am still the wrong person to give it.

Senator MALONE. Can you bring the right one?

Mr. GARRETT. The right one is completely out of my office, and in the office of a different Assistant Secretary.

Senator MALONE. You come back and bring a list of these people with whom you consult.

Mr. GARRETT. I will do that. But I would like very much that you could call someone from the right office who can give the figures you want from their own knowledge and you will get more satisfactory testimony on that score.

Senator MALONE. I do not understand your testimony. You are the coordinator of the three services.

Mr. GARRETT. Research and development only; nothing to do with procurement or plans as to production.

Senator MALONE. Have you through your research and development said to somebody that the alloys now available are not suitable to replace these parts? The titanium alloys now available?

Mr. GARRETT. No, sir; we have not said that.

Senator MALONE. If you have not, then we have to rely on someone who makes the plane.

Mr. GARRETT. I do not understand you.

Senator MALONE. You heard what one man said about it.

Mr. GARRETT. The aluminum alloys available are not suitable for these new planes.

Senator MALONE. No, I am talking about titanium alloys. You are in that.

Mr. GARRETT. We have all materials.

Senator MALONE. You consider this rather important, or do you?

Mr. GARRETT. One of the most important.

Senator MALONE. I have not gotten anything out of your testimony. Frankly, I am sorry. So you will come back tomorrow. We will have you tomorrow afternoon.

Mr. GARRETT. Yes, sir.

Senator MALONE. Mr. Promisel and Mr. Harwood of Naval Research.

Mr. Promisel, you were here this morning?

STATEMENT OF N. E. PROMISEL, BUREAU OF AERONAUTICS, NAVY DEPARTMENT, WASHINGTON, D. C.

Mr. PROMISEL. Yes, sir.

Senator MALONE. You know already the objectives of the committee. I hope you will identify yourself and your assistant for the purpose of the record. If you have a prepared statement, you may read it or you can make any statement you think will be helpful to the committee in determining the future of this metal in your business, and give us any information you think would be helpful.

Mr. PROMISEL. I am Nathan E. Promisel, head of the Materials Branch of the Airborne Equipment Division of the Bureau of Aeronautics. Mr. Harwood will introduce himself.

May I make one or two additional statements at this stage?

Senator MALONE. Yes.

Mr. PROMISEL. We received an invitation to be here some time Friday afternoon. Because of that fact, and because of illness, I arrived this morning without any prepared statement, and therefore any comments I make are personal extemporaneous and not necessarily the official opinions of the Navy.

Senator MALONE. I might say we are in entire sympathy with your position, and perhaps it is our fault that we did not notify you in time.

Mr. PROMISEL. That was not in criticism, but in explanation.

Senator MALONE. You are headquartered in Washington so you will be available to the committee.

Mr. PROMISEL. Yes, sir.

Senator MALONE. After you finish today, if you would like to prepare a brief or statement of any kind that would complete your testimony, it will be included.

Mr. PROMISEL. I would be very happy to, Senator.

Senator MALONE. Thank you. We want to be helpful but we cannot be unless we find out what you would like to do.

Mr. PROMISEL. I hope I can clarify that this afternoon.

Senator MALONE. Go right ahead.

Mr. PROMISEL. Perhaps it would be well to just go back and recite in retrospect the history as I see it over the past few years.

TITANIUM POSITION WITH OTHER METALS

When in 1946 the Bureau of Mines pamphlet, which is now so well recognized almost as a classic, became available pointing out the introduction of titanium, the handwriting on the wall was clear to us, that here was one of the most important materials for aircraft construction which we had seen, certainly during my time. Therefore, we promptly started to investigate its potentialities, and consider what we could do to expedite its introduction into the aircraft picture.

It has been stated many times, and is well known to everybody, how important weight is in aircraft. Many numbers have been mentioned. Just a few minutes ago you mentioned 1 pound perhaps being equivalent to 7 or 8.

I would like to say that under some conditions, depending on the airplane and the mach number and other technical performance requirements, that number may be in excess of 7 or 8 to 1. Depending upon the particular attributes of the aircraft, 1 pound saved at the

right time, which is while the aircraft is being designed on the draft board——

Senator MALONE. That is in the basic structure.

Mr. PROMISEL. That is correct, that 1 pound may well result in a saving of more than 7 or 8 pounds throughout the aircraft for reasons which you yourself have given. Therefore, it is essential that the aircraft industry and that we in the military have assurance at all stages, if we are going to properly exploit this material, that the material be available at the right time in the right quantity and in the right quality.

Senator MALONE. In other words, you do not dare take your plans off the drafting board until you know it is available.

Mr. PROMISEL. Unless the incentive is so great that we can take a calculated risk and depend on the minimum quantity that will be available and at least hope it will be available for these critical items, that is right, sir.

We therefore began at the Bureau of Aeronautics a research and development program aiming at exploring the possibilities, creating incentives for industry, establishing what the problems would be, attempting to solve some of these problems, aiding the aircraft industry in further exploring it on their own hook and trying to solve the more practical aspects of titanium development which an aircraft constructor would run into sooner or later.

Senator MALONE. You do work with the actual producers of the planes?

Mr. PROMISEL. Very closely. That program began almost immediately after the Bureau of Mines announcement and is still continuing.

Senator MALONE. What was the approximate date of that announcement?

Mr. PROMISEL. 1946.

Senator MALONE. That it did have a practical application in their opinion?

Mr. PROMISEL. It seemed to be clear at that time that we would have available titanium, and that the remarkable properties of the material indicated it was something we could not afford to overlook at that time.

So we immediately began to explore.

Senator MALONE. Do you join with those who say there is no second best air squadron in a fight for very long anyway?

Mr. PROMISEL. Definitely. The development program continued, and I think to a certain extent the development of titanium's history has been covered this morning thoroughly by the producers.

In the early stages, of course, in order to get know-how and get the proper feel of the material, titanium was substituted for existing materials. Then it began to be injected into future designs so as to take advantage of its unique combination of properties. It might be well, although I am sure this must have been given in previous testimony elsewhere, to briefly run through why we think this is such an important material.

Senator MALONE. I think it is very important that you do that, because of the uncertainty in the business. Certain decisions have to be made by officials, such as yourself, and you take a great responsibility in making those decisions. Unless several or all the Senators

and Congressmen have available the information, it is a great responsibility on you to say that you want to buy something at $15 a pound when somebody else might think you should only pay 50 cents a pound or a dollar a pound. Therefore, we can be helpful, if after we study the testimony, we make recommendations as to what should be done.

Mr. PROMISEL. Yes, sir. The immediately apparent and enticing properties of titanium as we saw them were its low specific gravity, its light weight combined with the relatively high strength properties which were intrinsic even to the unalloyed titanium, and particularly when alloys of titanium began to be developed.

Not only were these properties existent at room temperature but they were retained to a very gratifying degree as the temperature was increased. This was not characteristic of the commonly used light alloys in the aircraft construction field, namely, aluminum and magnesium, which, as has been said, began to drop significantly in strength at a temperature of a few hundred degrees Fahrenheit.

In addition, this material had excellent corrosion resistance under most of the conditions encountered in aircraft. It could be produced from ores that were abundant, or at least seemed to be then, and I believe still are.

Senator MALONE. In this Nation and adjacent areas.

Mr. PROMISEL. That is correct, sir.

Also, it was a nonmagnetic material and there are too few nonmagnetic materials of high strength and great availability available today for some of the more specialized and classified applications with which the military are concerned.

This combination of properties is particularly important when we consider the future of aircraft. The introduction of the jet engines and the turbo prop engines has indicated that there will be an ever-increasing temperature in the operation of aircraft, not only because of proximity to these high temperature operating pieces of equipment, but also due to the increase in speed which has already been mentioned a few minutes ago.

There were other things that increased temperatures, such as deicing systems and incidental equipment in aircraft. There is always in front of us this ever-increasing temperature pattern with which we must contend. The only alternative then to aluminum and magnesium would be stainless steel, or possibly some other alloy steels, and immediately then you encounter a weight penalty, since roughly you have a specific gravity of the order of 3 to 1, steel against aluminum. The intermediate position of titanium with respect to good properties at elevated temperatures, even in the early stages, and its prospect of enhancing these properties with development, then became one of the most intriguing things we encountered in aircraft to date, and I still feel that way about it after these years.

Nevertheless, as time went on it became clear that there would be factors which would militate against the expeditious use of this material, at least to the extent to which the aircraft industry would like to use it. The problems of availability became apparent. The cost of the material was considerable, and in some cases I believe proved to be a deterrent to extending the uses of it. There were certain technical problems of quality and uniformity in fabrication.

I would like to say at this stage, however, that certainly within recent periods, based on indirect information which we get, the improvement in quality and in uniformity has been very gratifying. I think the producers have been well aware of this problem and certainly have been trying to make progress in that field.

Senator MALONE. Is it not the history of production of materials that when it is advantageous financially or as in the case for national defense, these problems generally are solved?

Mr. PROMISEL. Yes, sir.

Senator MALONE. In other words, only a few short years ago aluminum and magnesium were in almost the same position that titanium is now in, with respect to the problems of price and availability.

Mr. PROMISEL. I would guess the major difference would be the time stage. We have tried to condense it into as brief a period as possible, because of the promise and importance of titanium.

Senator MALONE. If it were not for preparation for national defense, it would take many years now.

Mr. PROMISEL. I would suspect so, yes.

Senator MALONE. Go ahead.

Mr. PROMISEL. I do not know that there is much more I could add to this, unless you want to bring out certain points later. I myself am not immediately connected with the group that generates quantitative requirements. I know that is one of your big concerns now. As a matter of fact, the Aircraft Production Resources Agency so ably represented by the general here acts for the Bureau of Aeronautics and the Air Force, and I am sure has much more reliable figures than I. Furthermore many of these requirements are classified.

Senator MALONE. In your research for the Navy, are you convinced that it is a necessary material and only subject then to the decision of your superiors as to the extent of its use in planes due to its cost? You are satisfied from your research that it will replace these other materials and be more efficient?

Mr. PROMISEL. It will replace them to a great extent. I do not think any one material will ever be completely replaced.

Senator MALONE. I did not mean it would take the place of all aluminum and steel. I think we have testimony from the airplane manufacturers that they are looking forward to a 30- or 40-percent displacement of other materials. Would that seem reasonable to you?

Mr. PROMISEL. That would seem to be a reasonable figure.

Senator MALONE. And you are convinced from your research that up to that extent this material will do the work and be of a lighter weight and be just as strong and efficient in its use?

Mr. PROMISEL. In fact, I would go beyond that, Senator, and say that where it is properly used, it would be expected to do a better job than the materials presently used.

Senator MALONE. I presume its noncorrosive properties are a great thing for the Navy.

Mr. PROMISEL. They certainly are.

Senator MALONE. I can see why.

Mr. PROMISEL. It can do, based on experiments, what no other common material can do corrosionwise.

Senator MALONE. You think at the moment that it is just a question of the decision of the Department of National Defense as to how far it would go at the present price. It is a practical material.

Mr. PROMISEL. I do not think it is wholly a matter of a decision in respect to price because I think there are these practical aspects which have already been alluded to, such as assurance of availability.

Senator MALONE. You are not in the manufacture of titanium. You are entirely out of that business.

Mr. PROMISEL. Yes, sir.

Senator MALONE. We have had the actual producers of titanium testify before the committee. Another contract has been let to the Crane Co. We have heard a short statement in Los Angeles from either the president or vice president of that company. They are very enthusiastic about it. The contract, I believe, is for 15 tons per day. However, they are just selecting a place now to build their facilities. It will be some time before they are in production. The committee is getting all of the information it can possibly get before they complete the testimony on titanium as to its availability in the proper quality and quantity.

Speaking for one member of the Senate, from what we have heard here, I have little doubt that given the contracts, these people that want to get into this business, and the ones who are in it and want to enlarge production, it will be a comparatively short time before you will have all the material.

I am going to ask you, if the price were to be considered to be proper by your superiors, where else would titanium be used in the production of equipment in the Navy?

Mr. PROMISEL. May I refer you to Mr. Harwood, who I think will cover the Bureau of Ships and other groups of the Navy?

Senator MALONE. Yes. If you have any further statement, you might complete your statement.

Mr. PROMISEL. I have nothing further to state. I think you have covered the points I omitted.

Senator MALONE. Then, Mr. Harwood, would you identify yourself for the record?

STATEMENT OF JULIUS J. HARWOOD, HEAD, METALLURGY BRANCH, OFFICE OF RESEARCH, NAVY DEPARTMENT, WASHINGTON, D. C.

Mr. HARWOOD. My name is Julius J. Harwood. I am head of the Metallurgy Branch of the Office of Naval Research, Navy Department.

Like Mr. Promisel, Mr. Chairman, I would like to preface my remarks by saying that due to the relatively brief period of time we had, we are unable to present a consolidated Navy viewpoint. Some of my opinions may not necessarily be those of the Navy Department official policy.

NONFLIGHT USES FOR TITANIUM

As you pointed out, Mr. Chairman, there are other applications in the Navy Department besides aircraft. As a matter of fact, one might say in the Navy our interest encompasses not only the interest of the Air Force, through our Bureau of Aeronautics, and the interest of Army Ordnance through our Bureau of Ordnance, but we have particularly our shipboard applications.

There, as you would expect, we hope to take advantage of the outstanding corrosion resistance of titanium to salt water and marine environments. As a matter of fact, one could say that titanium is practically equivalent to platinum in its corrosion resistance to these environments.

Our Bureau of Ships has a very active prototype-evaluation program in testing titanium alloys and titanium for such applications. If you wish, I can mention some of the applications which are being considered.

Senator MALONE. I would like very much for you to do so.

Mr. HARWOOD. We have evaluated titanium for meter disks, for oil, gasoline and salt-water meters, and in all tests conducted to date, it has had outstanding resistance to corrosion in such applications.

It has been evaluated for wet exhaust mufflers for submarine diesel engines. There also the evaluation has gone ahead very satisfactorily.

It has been evaluated as a condenser tubing material and for such type of applications involving the handling of salt water, we have set up a pilot plant condenser system in North Carolina at one of the outdoor exposure stations.

In all these applications, and other applications which I will mention, there has been no deterioration of the material due to corrosion in the operating environment.

Senator MALONE. Is it more resistant to corrosion than any other material you have used?

NAVY SAYS "CORROSION-FREE PROPERTIES ESPECIALLY DESIRABLE"

Mr. HARWOOD. With respect to other commercial structural materials, yes, sir; for these types of environments.

It is being evaluated also for steam turbine blading; for valve trims in bronze and other type valves; hot water tanks; submarine snorkel tubes to replace stainless steel; applications in which exhaust gas exposure is required, salt water piping systems, salt water pumps, salt water pumping valves and propeller shaftings.

We have even considered the possibility of designing PT boats using titanium for hulls. This latter application has been abandoned because there is very little weight saving one can realize because of the fact we are now using thin gauge aluminum to begin with. The use of titanium might require reinforced structures which would increase the weight substantially, and at the present price would make such a titanium PT boat almost exorbitant.

Even though titanium does exhibit in these and other shipboard applications outstanding resistance to corrosion, there are commercial materials now being used which while not as satisfactory, still give us a definite service life. So one has to take into consideration in the possible substitution of titanium for these materials the original cost, replacement cost, and maintenance costs, in determining the material choice for any given application.

The conclusion has generally been reached for shipboard applications that there are few applications in Navy shipbuilding programs where the use of titanium is mandatory to meet specifications for the particular components or where, by the use of titanium, a distinct military advantage would be realized. Thus the main conclusion which

we come to for these shipboard applications is that if the cost of titanium reaches a competitive position with commercial materials which we are now using, the extent of applications would rise tremendously. At the moment our Bureau of Ships requirements are presently very small because of the high cost of titanium, and titanium alloys. With respect to ordnance applications in general I would expect our Navy position to be somewhat similar to that of the statements which Colonel Mesick made. We probably would not have as extensive ordnance applications as Army Ordnance because of the difference in size of the two operating groups. We are evaluating it for ballistic purposes, and other gun component purposes.

Many of the ordnance applications I am not at liberty to discuss in open session. In general, I think we can only conclude that the properties of titanium indicate very definitely it is a natural for many of our military applications.

Senator MALONE. In other words, in balancing the life of the equipment where the weight is not too much of a factor, at the present cost many of the applications which would be practical at a competitive cost, would not be in the picture.

Mr. HARWOOD. That is correct, sir.

Senator MALONE. There has been testimony that, instead of $15 a pound for this sheet, it might be substantially reduced. What does stainless steel and steel alloys and aluminum alloys cost for your PT boats?

Mr. HARWOOD. I think, in general, while I am not too familiar with the figures, we can use a figure of $1 a pound approximately for stainless steel and highly alloyed aluminum sheet and shapes.

Senator MALONE. Suppose that, instead of $15 a pound, titanium came down to $5 a pound for sheet material ready to be molded into the shapes you wanted, the uses of the material would increase?

Mr. HARWOOD. It would increase the interest and accelerate the possibility of more use because we would consider not only the original cost but also replacement costs. If we did not have to replace the component, a very definite advantage is realized. I would say that, with a price under $5 a pound for finished shape, titanium alloys would certainly have a much more increased interest to our shipbuilding people.

Senator MALONE. Do you have any knowledge how competitive it would have to be in cost to be used in the hulls of larger ships?

Mr. HARWOOD. I do not think I could answer that question personally.

Senator MALONE. Could you make a few inquiries?

Mr. HARWOOD. Yes, sir. By larger ships you would mean destroyers possibly?

Senator MALONE. Yes; I think so. I was in the field artillery myself. I knew very little about the Navy. What I did see of it I liked.

Mr. HARWOOD. The claim has been made for certain types of applications, such as valve trims and simple shapes.

Senator MALONE. And for chemical use in chemical affairs. I suppose that would be limited in the Navy.

Mr. HARWOOD. I would like to make this point, Senator. At least one company, and probably others, can do it, has made the claim that for a large enough production, for simple type shapes, by the use of

certain manufacturing or fabricating techniques, that these shapes can be made competitive with today's price of stainless steel and other alloys. In other words, titanium valve trims can be made competitive with monel or stainless-steel valve trims. We are currently evaluating such techniques.

Senator MALONE. With respect to these articles of equipment you have described, have you made any estimate of tonnage on an annual basis for which there might be a demand, if you could count on titanium being available? Just forget about the uniformity and workability; just suppose it were available like stainless steel or aluminum.

Mr. HARWOOD. At present prices?

Senator MALONE. Yes.

Mr. HARWOOD. Most of the Navy requirements would be essentially those of our Bureau of Aeronautics, together with limited ordnance requirements, and a few shipboard uses. That is at present prices.

Senator MALONE. Leaving out the airplanes, just for the uses you mentioned awhile ago, do you have any estimate of tonnage which would be used assuming that all the alloys are practicable and available?

Mr. HARWOOD. How much we would use, other than aircraft components, at present prices?

Senator MALONE. Yes.

Mr. HARWOOD. I do not have the figures. I imagine it would be in the order of small tonnage.

Senator MALONE. If you would care to submit an additional statement to the committee, just address it to the chairman in care of the Senate Office Building, as to requirements at present prices; then assume $10 and $5 a pound for the material to give the committee some idea of what the difference in consumption might be as the price was reduced, speaking for just one Member of the Senate, and with the testimony we have had here, I think that would be very helpful.

I might say that from the testimony we have heard from manufacturers and potential manufacturers, who would like to get into the business, I would not be at all surprised to see a material reduction in cost in the reasonably near future, because there is so much laboratory work being done on new processes. I think somebody will come up with something.

Mr. HARWOOD. As I understand, Senator, you would like the estimated tonnage we might use, on other than aircraft.

Senator MALONE. Yes; because we have a pretty good estimate from the aircraft manufacturers that I think would suffice for the committee. They of course being the ones who make the aircraft to certain specifications.

Mr. HARWOOD. I would like to make one more comment, if I may. Mr. Garrett mentioned the basic research program in the extractive metallurgy of titanium that the Office of Naval Research is currently investigating for the Department of Defense. I would like to say that the motivation that led to this program, which is spread over 13 different contractors, was to increase the availability of sponge titanium. The program as such is not aimed at a new process development in any way, but has the objective of obtaining fundamental and basic data which may be useful in expediting the growth of continuous

processes based on the present production process or coming up with data which might be useful to people who are actively trying to find new processes. This data will be widely disseminated and made available to the full titanium industry on an open basis.

Senator MALONE. That is the work of your department.

Mr. HARWOOD. Yes, sir.

Senator MALONE. Is there any other department that may be working closer on a quantitative basis?

Mr. HARWOOD. In respect to estimated tonnage requirements?

Senator MALONE. Yes.

Mr. HARWOOD. Such information is coordinated through the Office of Naval Materiel.

Senator MALONE. Then you would have the information and could submit it in a short brief to the committee?

Mr. HARWOOD. We can try to get it for you.

Senator MALONE. Thank you.

(The information is as follows:)

DEPARTMENT OF THE NAVY,
OFFICE OF NAVAL RESEARCH,
Washington, D. C., December 4, 1953.

Hon. GEORGE W. MALONE,
United States Senate, Washington, D. C.

MY DEAR SENATOR MALONE: During the November 23 hearing of the Senate Subcommittee on Minerals, Materials, and Fuels, at which Mr. N. E. Promisel, of the Bureau of Aeronautics, and Mr. J. J. Harwood, of the Office of Naval Research, testified, you expressed interest in receiving information concerning the estimated Navy tonnage requirements for titanium for other than aircraft applications if the price of titanium was reduced from $15 per pound to $10 per pound or $5 per pound. You also expressed interest in knowing the price level at which titanium alloy plate might receive serious consideration as a hull material in naval vessels such as destroyers.

You may recall from the testimony provided at the hearings that, unlike the aircraft requirements, in which we may include guided-missile and rocket applications because of their requirements similarity, there are few applications in the Navy's shipbuilding program in which the use of titanium is a "must" to meet specifications and performance characteristics, or where a distinct military advantage would be realized at this time by the use of titanium. However, it was pointed out that, if the price of titanium reaches a competitive position with commercial materials now being used in such applications, the ultimate requirements for shipboard applications would be significant, particularly for such uses as piping systems and condenser tubing, provided, of course, titanium proves technically acceptable for these applications. The shipboard components for which titanium is now receiving active evaluation and prototype development utilize mainly copper base alloys, nickel-copper alloys, and stainless steels.

A preliminary survey reveals that a reduction in price of titanium mill products and finished shapes to $5 per pound would not result in any significant increase of shipboard requirements for titanium. Not until the cost is reduced to approximately twice that of the commercial alloys mentioned above, will titanium approach a competitive position for these applications. At such a price range, 1,000 to 1,500 tons of titanium per year might be used in current naval shipbuilding and ship maintenance programs. In order to receive extensive structural usage aboard naval vessels the price of titanium must be reduced to $1 per pound or less. At this competitive price 5,000 tons per year might be required for shipboard components and accessories, based on wartime production schedules.

Our naval ordnance evaluation and prototype development programs, for other than missile and rocket applications, are not sufficiently advanced to permit any reasonable estimate of requirements based upon costs. Many of the proposed naval ordnance applications depend upon improvements in the technology and properties of titanium alloys. It is only logical to assume, however, that the naval ordnance uses of titanium would reach a significant tonnage level with a substantial price reduction.

With respect to the use of titanium plate as hull material for naval vessels, service performance, such as ballistic properties and fouling behavior, must be considered in addition to cost and potential weight advantages. For small craft, such as PT boats, titanium provides no increased military advantage over aluminum alloys, for present designs. For larger vessels, such as destroyers, the current status of the technology of titanium alloys does not make their consideration feasible for such uses. Assuming that titanium alloys and fabricating techniques will be developed to produce plate material comparable to alloy steel plate, it might be anticipated that titanium would have to reach a competitive price position with alloy steels to be considered for structural hull applications. It should be noted that strength/weight structural advantages, comparable or superior to those offered by the use of titanium alloys, can be obtained by the utilization of heat-treated or special alloy steels for hull plate. Often, as with titanium, the technical problems associated with the fabrication of such steels combined with their higher costs outweigh the overall advantages which might be gained by their use.

The Bureau of Aeronautics representative would like to take this opportunity to emphasize again the importance of titanium in naval aircraft and to cite specific applications therein. As stated during his testimony, the Bureau of Aeronautics as early as 1946 was actively promoting the development and use of titanium in naval aircraft. Because of its very impressive weight-saving possibilities, corrosion resistance, and good elevated temperature properties, and the important advantage of domestic availability of titanium ores, it was envisaged that titanium and its alloys would be particularly suited to the growing need for improved materials for jet aircraft construction, particularly in the very high performance, supersonic types. As a result, today titanium is being used by Navy contractors in practically all experimental and in a number of production airplanes. Specifically, items that have now been reduced to the practical application category through cooperative development effort with Navy contractors include jet engine compressor disks, blades, and related components such as through-bolts and spacers, firewalls, shrouds, baffles, gun blast tubes, access doors and panels, and miscellaneous ductings and forgings.

The Bureau of Aeronautics is also exploring under contract such other major items as titanium armor, propeller blades, landing gear components, hydraulic tubing, and titanium aircraft fasteners with excellent promise of successful utilization of titanium in these applications.

The undersigned will be very pleased to comment further on the above or other items if you so desire and appreciate the opportunity afforded to express their opinions on this important subject.

Sincerely yours,

J. J. HARWOOD,
Head, Metallurgy Branch, Office of Naval Research.
N. E. PROMISEL,
Head, Materials Branch, Bureau of Aeronautics.

Senator MALONE. Do you have any further statement?

Mr. PROMISEL. No, sir.

Senator MALONE. Thank you very much. If you have any additional statement or brief, you may submit it to the committee.

Mr. PROMISEL. Thank you, sir.

Senator MALONE. Now, we have Mr. C. M. Gelhouse of Fairchild Engine and Airplane Corp.

Will you come forward. We have heard considerable testimony on the use of titanium material in the manufacture of engines.

STATEMENT OF C. M. GEHLHAUS, FAIRCHILD ENGINE & AIRPLANE CORP., HAGERSTOWN, MD.

Mr. GEHLHAUS. I am from the aircraft division and not the engine division, sir.

Senator MALONE. We have had very little testimony as to the extent for the use of the material in engine manufacture. So Mr. Gehlhaus, will you identify yourself for the committee, and if you have a state-

ment you would like to make, or any comments or a statement to submit, we would appreciate it.

Mr. GEHLHAUS. The name is Charles Gehlhaus, and I am from the Fairchild Aircraft Division in Hagerstown, Md., in the materials department.

Senator MALONE. You are in the aircraft division of Fairchild.

Mr. GEHLHAUS. Yes, this is correct.

USES OF TITANIUM

Senator MALONE. In your title I was led to believe you were in the engine division. Nevertheless, you go ahead and maybe you can give us some information anyway.

Mr. GEHLHAUS. All right, sir. We have been submitting data on titanium for quite some time now, and I believe that the present program within the aircraft industry is satisfactory and very effective as regards the compilation of these requirements for titanium. The program was set up under the Aircraft Production Resources Agency at Wright Field and periodically the airframe companies file a set form stating their immediate forecast of requirements and future forecast of requirements. On the basis of availability, I understand that these requirements are then evaluated in AMC at Wright Field on the basis of the most effective use for immediate defense requirements and a policy has been established accordingly.

We at Fairchild at Hagerstown are not using titanium at the present time because we are building the flying boxcar, which is a reciprocal-engine aircraft, and there are other aircraft which are more directly in need of titanium for specific requirements.

We had proposed, however, back in 1952—I have some figures here—at which time we took the most optimistic view that the material would be available in quantity and quality, and at that time we estimated that we would be able to use approximately 1,400 pounds per airplane.

Senator MALONE. What is the weight of the plane in which you would use 1,400 pounds?

Mr. GEHLHAUS. I believe it is approximately 28,000 pounds. (Correct figure is 29,067 pounds and refers to "Gross Metallic Airframe Weight".) I am not certain on that. I could check it. More recently, however, because of the status of the availability of titanium, on the last application, or the last report establishing these requirements, we set it up at approximately 100 pounds or a specific engineering change proposal. That change proposal, however, has not been finalized in its evaluation out at the field, and we are not doing anything at all in the way of using titanium.

I thought it would help to refer here—I am sure you have been in discussions with the west-coast airframe people—that there was quite an extensive report prepared by the airframe member companies of the Aircraft Industries Association back on May 1, 1953. Have you had access to that report, sir?

Senator MALONE. No.

Mr. GEHLHAUS. This is a report compiled by the Aircraft Industries Association and typed up by Boeing Airplane Co.

Mr. ADLERMAN. I think we are getting that.

Mr. GEHLHAUS. They sent out a uniform questionnaire to all airframe manufacturers and set forth the considerations that were to be

evaluated and requested quite detailed data, which has been set forth in very compact and intelligible form.

I am sure it will answer practically any question as regards plane requirements, in addition to, of course, the firm figures which are being forwarded to Wright Field.

Being in the materials department, I think that is about as much as I care to comment on at this time. If there is anything we can get you in the way of specific answers to specific questions, I will be happy to do so.

(Discussion off the record.)

Senator MALONE. I am interested in Fairchild aircraft just as in the other manufacturers who have established a reputation. The committee is looking for information so that it can be helpful. We know mistakes have been made, and we know there will be more mistakes made. If the committee decides from the testimony that more production is necessary from the point of view of national defense and for commercial aircraft, more mistakes are likely to be made in trying to increase production. But the greatest mistake would be to send our boys up in planes that would not fly quite as fast or as far as some other potential enemy's planes. The only source for certain information is the manufacturer of the planes and the engines. So when you recommended use of 1,400 pounds in a 28,000-pound airplane, would that improve the maneuverability and the general efficiency of the plane, if you are able to secure this material?

Mr. GEHLHAUS. The only indication I have here is that it would have affected a weight savings in the aircraft and would not appreciably affect the performance.

Senator MALONE. What does the weight saving mean in a plane?

Mr. GEHLHAUS. Of course, I am not the technically qualified man to give you the answer. However, I did get around and discuss this thing with the engineering boys, some of the other material fellows, and I was interested in the comment, or the data that was expressed by Mr. Douglas, saying that a pound of airframe weight or an excess pound of airframe weight is worth $40 or $25.

I was interested in ascertaining something definite along that line myself. The only thing I could get from the engineering people on the subject is that it is a very controversial evaluation at best.

Senator MALONE. We have not heard very much controversy about it. If you will give us the name of the man from your organization who will know about the engines, we will call him. Who is it?

Mr. GEHLHAUS. If you get hold of Mr. W. L. Landers and tell him you are specifically interested in engine weight evaluation.

Senator MALONE. Where is he?

Mr. GEHLHAUS. He is up at Hagerstown. He is vice president of the corporation.

Senator MALONE. Can he come down tomorrow?

Mr. GEHLHAUS. I shall find out. I think he is occupied somewhat.

Senator MALONE. We may be here Wednesday morning, but I am not sure of that. We would hear him Wednesday morning if that is as early as he can get here. You see, the information we get on planes is that if you save 1,400 pounds in weight, you could then carry additional fuel and increase the range of the plane.

Mr. GEHLHAUS. There is no question, sir, about that.

Senator MALONE. Or it could carry more bombs, passengers, or more soldiers. I do not understand your statement that you do not know exactly what it means.

Mr. GEHLHAUS. You probably misinterpreted what I said. I said that to say there is a uniform method of measuring a pound of airframe weight saved which would be applicable let us say to all aircraft is the controversy point. That there would be an appreciable saving is without question.

Senator MALONE. I did not understand that anybody said that you could evaluate it exactly. I think you will find the testimony ran from $25 to $40 a pound. While Douglas and Gross of Lockheed said that one pound saved in correct place might mean a 7- or 8-pound saving throughout the aircraft. Mr. Promisel of the Navy testified it might run higher than that. They all agreed there is a tremendous saving.

Mr. GEHLHAUS. There is no question there.

Senator MALONE. Let us start out with that assumption and get away from the controversy. Make your own estimate. So what would this 1,400 pounds do to this plane if you had the titanium?

Mr. GEHLHAUS. I would guess that if we had the titanium that there would be approximately—I would assume from the figures I have here—of this 1,400 pounds of titanium, we would put in the aircraft, eight-hundred-and-eighty-some-odd pounds are presently stainless-steel design, which would mean that we would gain approximately 43 percent of the weight there.

Senator MALONE. Forty-three percent of the 1,400 pounds would be saved?

Mr. GEHLHAUS. In other words, of the 1,400 we will take 880 pounds and say we save 43 percent of it.

Senator MALONE. Say you have 400 pounds, and it is worth $40 a pound, or $16,000.

Mr. GEHLHAUS. The difference between the 880 and the 1,400 pounds of course would not necessarily reflect. I do not know what materials they are planning to displace.

Senator MALONE. They say that this is somewhere in the neighborhood of twice the weight, so you would have about half the weight that you have with steel; is that right?

Mr. GEHLHAUS. That is correct.

Senator MALONE. What does that mean? Do you think it is a better plane?

Mr. GEHLHAUS. I can get a firm estimate and submit it.

Senator MALONE. We do not need a firm estimate.

Mr. GEHLHAUS. I mean a reasonably good one from one of the qualified people in our engineering department.

Senator MALONE. All right. Then you submit a brief on what in their considered opinion would be the saving if you had the 1,400 pounds you asked for, which I understand you did not get.

Mr. GEHLHAUS. That is correct.

Senator MALONE. You did not get it because it was not available.

Mr. GEHLHAUS. That is right.

Senator MALONE. The committee is trying to help make it available. We want to know what it would do for you if you had it. What do you think?

Mr. GEHLHAUS. I think that is all right.

Senator MALONE. What kind of additional maneuverability or additional range would be involved?

WEIGHT-SAVING FEATURES OF TITANIUM

Mr. GEHLHAUS. I think it would probably allow for a larger cargo-carrying capacity.

Senator MALONE. Is not that what you are complaining about all the time? It would be just as safe a plane, just as strong.

Mr. GEHLHAUS. If the titanium were used, it would be.

Senator MALONE. In other words, with such a strong and safe plane, you would save six or seven hundred pounds that could be used for fuel, bombs, or soldiers in a military plane or anything else.

Mr. GEHLHAUS. I am sure that is so.

Senator MALONE. That is what I asked you to start with. I don't want to describe your plane. You tell us.

Mr. GEHLHAUS. The point I am getting at is that we stated that the weight-saving advantage would be great. There are other considerations here. We must look at the picture from an immediate assessment and a long-range assessment. If we take all these premises and say that the material will be available, that its cost will be comparative——

Senator MALONE. Do not bother with the cost. You are making warplanes. Let us just assume titanium is available; what would you do?

Mr. GEHLHAUS. If it were available and in quality we would put this 1,400 pounds in the airplane.

Senator MALONE. Is that all you would put in?

Mr. GEHLHAUS. No, sir, not necessarily, but we have immediate planning for the use of 1,400 pounds. Ultimately we would go as far as would be practical to go where we could gain an advantage.

Senator MALONE. We have had testimony from experts, including Mr. Douglas, of Douglas Aircraft. Mr. Gross, of Lockheed, and the representative from Boeing that perhaps you would run eventually to 30 or 40 percent.

Mr. GEHLHAUS. Thirty percent is the figure we calculated.

Senator MALONE. That 1,400 pounds is not 30 percent.

Mr. GEHLHAUS. That is for the future.

Senator MALONE. That is what I am talking about. I am not talking about today. We are not going to help any planes already made. How much titanium would you use in your plane if titanium were available tomorrow and the Government was paying for it?

Mr. GEHLHAUS. That is our figure, 1,400 pounds.

Senator MALONE. It was not the last figure you mentioned, 30 percent.

Mr. GEHLHAUS. The 30 percent is long range.

Senator MALONE. What do you think we are talking about, history? We are talking about long range.

Mr. GEHLHAUS. You are saying if it was available tomorrow. You have two conditions.

Senator MALONE. If it is available tomorrow and from then on, what would you start out and try to do?

Mr. GEHLHAUS. The objective of course would be to use it wherever it has an advantage. Our engineering people have evaluated the

design, come up with 1,400 pounds that they feel there would be a definite good advantage for using titanium. Whether they would ultimately come up with more pounds specifically and actually work at it from the usability standpoint, I do not know.

Senator MALONE. Would you send in a brief after you go home and consult with your engineers?

Mr. GEHLHAUS. I would be happy to. As I explained to you, I am from the requirements section.

Senator MALONE. The requirements is what we want to know about, but you do not know about that.

Mr. GEHLHAUS. I think I gave you the figure there.

Senator MALONE. The 1,400 pounds does not mean anything because you yourself say it would run up to 30 percent finally. You just testified to that figure.

Mr. GEHLHAUS. The figure that we submitted on this long-range program, not necessarily for this airplane. I do not know that either; that could be for some future aircraft.

Senator MALONE. I do not know, so I do not think we can go any further. We would be very glad if you would submit a statement to the committee after you go back and find out what your engineers might do over the years ahead, if they were assured of a supply of titanium, the workability and the quality of which would fit your requirements.

Mr. GEHLHAUS. We could do that.

Senator MALONE. We had no trouble with the other airplane companies. They went ahead and told us, because we do not know. Otherwise we would not be hearing you.

Mr. GEHLHAUS. I think maybe you are misinterpreting what I am trying to say, or maybe I am not making myself clear. I have the detailed listings to account for the 1,400 pounds; in other words, specific applications in the airplane.

Senator MALONE. I understand that.

Mr. GEHLHAUS. The report I have indicates that ultimately 30 percent of future aircraft would contain titanium.

Senator MALONE. Is this in your report?

Mr. GEHLHAUS. I have in report data form that has been submitted through Wright Field. How we would specifically and for what parts use this 30 percent, I do not know, or when we would get around to using the 30 percent I do not know. It is a future potential requirement.

Senator MALONE. That is what we would like to hear about.

Mr. GEHLHAUS. We will give you more specific detailed information.

Senator MALONE. Is this your written statement?

Mr. GEHLHAUS. I have no written statement prepared. I did not know exactly what specific information you require or would like to get.

Senator MALONE. You do not want to leave with the committee that 1,400 pounds is all the titanium you are ever going to use in one of your planes.

Mr. GEHLHAUS. No.

Senator MALONE. What do you want to leave with the committee?

Mr. GEHLHAUS. That we would ultimately get up to around 30 percent of aircraft weight.

Senator MALONE. And if titanium were available in sufficient quantity and quality and you put your engineers to work as you do when using aluminum and steel, how long would it be before you might start to build a plane that would consist of 20 to 30 percent titanium? If you knew you had it available.

Mr. GEHLHAUS. I am just guessing on this. I am not actually qualified to answer it. I would estimate that it would probably be about 2 years.

Senator MALONE. This is in the new design. Would you jump from 1,400 pounds to 30 percent of 28,000, which would be somewhere around 8,000 or 10,000 pounds of titanium in that period of time?

Mr. GEHLHAUS. That is the situation I have from these statistics.

Senator MALONE. There is no intermediate then. It would be a new design. If you knew it would be available, you would start out and design a new plane that would contain 30 to 35 percent titanium?

Mr. GEHLHAUS. Yes, sir. I can get more specific data, as I say. Our people are aware of this titanium development and they have kept their finger on it. They have designed the presently designed aircraft flying today. They said if it were available today they have specific applications in the aircraft where they could use 1,400 pounds, and would like to use, based on the information that is available at the present time as regards usability. Let us say we get into this question of bolts and nuts and other pieces which add considerable weight to the airplane. If they could be available in titanium at a weight saving, naturally we would use them.

Senator MALONE. You can make any part, whether it is a bolt, a nut, or a screw or anything, if you have the titanium?

Mr. GEHLHAUS. That is right.

Senator MALONE. We are really talking about the availability of titanium. Would you not use it, then, if you had it?

Mr. GEHLHAUS. I would say that——

Senator MALONE. I do not want to persuade you to make a statement. I am trying to help you.

Mr. GEHLHAUS. If the design allowed it and it was for weight saving, we would undoubtedly get into it and use it.

Senator MALONE. How long would that take to design this plane that you do not have started at all?

Mr. GEHLHAUS. I am assuming that there is some design on a new plane.

Senator MALONE. I think you will find that there is at the present time because we have testimony already that these designs are on the boards of other companies, and they just do not dare to take them off.

Mr. GEHLHAUS. That is right. I am sure that is our position also.

Senator MALONE. You see what the committee is trying to do, not to force you to make a plane containing 30 percent titanium, but to find out what you would do if you had a greater supply of titanium, because the committee might be helpful in getting you titanium.

Mr. GEHLHAUS. I can only stand on the data which I have been able to get from our engineering people which indicate in this report that they would use 30 percent of the airframe weight ultimately.

Senator MALONE. Do you want to submit any part of that report for the record?

Mr. GEHLHAUS. This report is available. We submitted the data in the same form that this consolidated report has been gathered and it is available from the AIA.

Senator MALONE. Whom did you submit it to?

Mr. GEHLHAUS. It was stated to the Aircraft Industries Association, and Boeing compiled it and collated it and put it in graph form.

Senator MALONE. We have the testimony from the other aircraft companies, and it is very satisfactory. If you have any material that you would like to submit to the committee, if it is of reasonable size, we will just make it a part of your testimony. If it is a larger report, we could accept it as an exhibit.

Mr. GEHLHAUS. The only thing I would like to do would be to go back and get together with our engineering people and we will submit this report as to the usability of the 1,400 pounds in the presently designed aircraft.

(This data was not furnished at the time the hearings were printed. When furnished they will be included in the committee files.)

Senator MALONE. How long ago did you submit that design to the Air Force?

Mr. GEHLHAUS. About 2 years.

Senator MALONE. I expect that is obsolete by now.

Mr. GEHLHAUS. I checked with our engineering people and they said that was the optimistic evaluation for design at that time.

Senator MALONE. Three years ago?

Mr. GEHLHAUS. Two years ago. I agree there are probably new forms.

Senator MALONE. I do not think that would be of any value to the committee because if you can believe Mr. Douglas of Douglas Aircraft, and Mr. Gross of Lockheed, and the representative of Boeing and others we are so far ahead of that 1,400 pounds that would just take up the time of the committee. It would be of no avail.

Mr. GEHLHAUS. You must appreciate that there is a big difference between the type aircraft we are producing at Hagerstown and the type of aircraft Douglas and North American are.

Senator MALONE. What is the type you are producing?

Mr. GEHLHAUS. It is a cargo transport, reciprocal engine. Once you get into the jet field, with high speeds and high temperatures and so on and so forth, there is a much greater advantage to be gained.

Senator MALONE. Is not the weight quite an advantage in a cargo plane?

Mr. GEHLHAUS. It certainly is. I am not minimizing the advantage of weight, but the advantage to be gained in design of jet-type aircraft is greater.

Senator MALONE. What would be the speed of this aircraft that you are talking about?

Mr. GEHLHAUS. Which one?

Senator MALONE. That you are using the 1,400 pounds of titanium.

Mr. GEHLHAUS. You mean the one we are producing. About 200 miles an hour.

Senator MALONE. You do not think that cargo plane is going very far in wartime, do you, or do you, at 200 miles an hour?

Mr. GEHLHAUS. It is designed to do a specific task.

Senator MALONE. Here at home?

Mr. GEHLHAUS. As far as I understand, it does a satisfactory job.

Senator MALONE. Where they are being used at 200 miles an hour?

Mr. GEHLHAUS. Senator, it is a cargo-troop-carrier aircraft. It was used in Korea and would be used for cargo drops and supplying advance forces with weapons and equipment on a cargo-drop basis, I assume, in any conflict. It has a very definite purpose and use in a rounded-out air force. It is not a combat aircraft. It is a support aircraft completely, but highly essential.

Senator MALONE. That would be used if we were to be sending a cargo overseas?

Mr. GEHLHAUS. Undoubtedly not. It would be based closer to operations.

Senator MALONE. It would be a very short haul.

Mr. GEHLHAUS. Yes, sir, relatively short.

Senator MALONE. Maybe it does not matter what it is made out of. That is the only type plane you are making?

Mr. GEHLHAUS. Yes, sir, at the present time.

Senator MALONE. And you do not know anything about the engine?

Mr. GEHLHAUS. No, sir. I am not qualified in that field. I was interested to know whether you wanted to hear from the engine people?

Senator MALONE. Yes, I would like very much to hear from them.

Mr. GEHLHAUS. All right.

Senator MALONE. But if the engines are for planes only going 200 miles per hour, the chances are that their testimony would not be of very great value.

Mr. GEHLHAUS. The engines we use on this aircraft are Curtiss-Wright engines. The Engine Division we have in Long Island does separate work, and they go into a small auxiliary jet engine.

Senator MALONE. But you do not know anything about those engines?

Mr. GEHLHAUS. No, sir.

Senator MALONE. You are only making a cargo plane with a speed of about 200 miles an hour. That is the plane in which you would use 1,400 pounds of titanium?

Mr. GEHLHAUS. That is right.

Senator MALONE. You complete your statement on that particular setup; just go right ahead.

Mr. GEHLHAUS. I am just about finished.

Senator MALONE. Do you have any excerpts from your report that you would like to read into the record?

Mr. GEHLHAUS. Not particularly, sir.

Senator MALONE. Then we appreciate having you here.

Mr. GEHLHAUS. Thank you.

Senator MALONE. Mr. William O'Donnell, of Republic Aviation Corp. You are familiar with the objectives of the committee. You represent the Republic Aviation Co.

STATEMENT OF WILLIAM O'DONNELL, REPUBLIC AVIATION CORP., FARMINGDALE, LONG ISLAND, N. Y.

Mr. O'DONNELL. Yes.

Senator MALONE. Would you identify yourself for the purpose of the record, and make any statement you care to make. Do you have a prepared statement?

Mr. O'DONNELL. No, sir.

Senator MALONE. You may proceed in your own way.

Mr. O'DONNELL. I am William J. O'Donnell, and I am chief development engineer at Republic Aviation Corp. We are interested in the titanium programs, and we started work on titanium back in 1951. I would like to divide the work which we did on the titanium into two parts.

FIRST USES FOR TITANIUM

The first part was with pure titanium. We investigated the possibility of replacement of stainless steel in firewalls, ammunition boxes and the like, to try and use it first on our F–84–F airplane, which is the Thunderstreak. In 1950 and early 1951 we were advised by the Air Materiel Command that they were not sure that we could get sufficient titanium to fulfill the high production requirements of the airplane. We therefore did not design the airplane for titanium at that time.

However, we did run through a company sponsored test program. We built a shroud, which is a firewall that goes around the tailpipe of the airplane, and we flew it and tested it. It was quite successful. We learned how to weld and form beads on the shroud itself. We also built the ammunition boxes for the forward section of the airplane. They are now ready for production. We have fully tested them. We actually used them. We fired 10,000 rounds of ammunition and found they worked very well.

We have proposed to the Air Force to install both these ammunition boxes and also the aft end of the shroud which forms the ejector, as we call it on the airplane, made of titanium in place of stainless steel. We expect that we will use about 130 pounds of this commercially pure titanium in the F–84–F, and the resulting weight saving would be about 50 pounds.

We have not yet established the effectivity of this change. We are awaiting approval of the change from AMC. The proposal has been out there for quite some time.

That is one particular use of titanium where we were not particularly interested in the strength at high temperatures. We were more interested in using a commercially pure titanium.

We have also been very interested in using the alloys developed for high strength at high temperatures. We have under development several classified projects in which we are planning to use titanium. We are conducting tests both by our production research and development group to determine how to form material and how it can be machined, and also by our research engineering group to determine the properties of the material at high temperatures.

Along with that we began testing in 1951 on the machining of bars, of RC–130 alloy—130 stands for 130,000 pounds per square inch. The material has good properties at elevated temperatures. We found out that it could be machined without too much trouble. We started forming alloy sheets in small samples in 1952, and we have formed many sheets of alloy now. We are quite certain that it can be used to form even a complete plane out of titanium if the need arises for it.

Senator MALONE. That would result in a very large saving, would it not?

AIRCRAFT PROJECTS PLANNED USING ALL TITANIUM

Mr. O'DONNELL. It would, provided the airplane was designed to operate at very high speeds. It would not if the airplane were designed to operate at transonic speeds. It is a question of the speed at which the plane flies. There are several places in the airplane where the temperatures of the structure might be above that, for which you would want to use aluminum. You would want structural frames near the aft end of the aircraft, and in that case you might use titanium at a speed of Mach I. There are certain portions such as the wing that you would not use titanium.

Senator MALONE. You would make it completely out of titanium?

Mr. O'DONNELL. The speeds would have to be much higher than Mach II. Missiles and such things can be designed now out of titanium, we believe. If the Air Force supports a program of this sort, we believe that you would be able to fly at these higher Mach numbers at which you could not fly with the use of aluminum, and you would save considerable weight over using steel.

Senator MALONE. What speed do you include in that category?

Mr. O'DONNELL. I will speak in general terms rather than giving you classified information. It is a difficult question sometimes.

Senator MALONE. We do not want any classified information.

Mr. O'DONNELL. You can say a skin temperature; if you are flying at Mach II would approximately 250° Fahrenheit, at which point you should start the changeover to titanium. That is about 1,150 knots above 35,000 feet.

Senator MALONE. How many miles?

Mr. O'DONNELL. That is about 1,350 miles an hour. For any airplane flying above 1,200 miles an hour you might tend to go to titanium. I might mention that aluminum can be used to temperatures of 300 degrees, but the advantage over titanium becomes smaller and smaller.

Senator MALONE. What would be the advantage if you could substitute titanium? Is not titanium lighter with the same strength?

Mr. O'DONNELL. It is not up to about three-hundred-some-odd degrees.

Senator MALONE. Because you have to have thicker titanium than aluminum?

WHAT TITANIUM CAN DO

Mr. O'DONNELL. Heavier titanium than aluminum. If you take the ratio of strength to density you find you should use aluminum up to temperatures of around 300°. You should use titanium between 300° and possibily 700° to 900°, and above that you use special stainless steels. There is a particular range in temperature at which you would use titanium.

Senator MALONE. I do not quite understand your explanation of the relationship of the weight between the two. I have been given to understand that the same strength in titanium would be lighter than aluminum.

Mr. O'DONNELL. No; that is not true.

Senator MALONE. What is the comparison?

Mr. O'DONNELL. We will take some allowable stresses. I will say that the ultimate stress of aluminum is around 85,000 pounds per square inch. The ultimate strength of some of the alloys of titanium

is around 135,000 per square inch, but the titanium weighs about 1.6 to 1.7 times the aluminum. So, if you take the ratio of those you will see that.

Senator MALONE. For the same strength?

Mr. O'DONNELL. No, I am sorry—for the weight. I am getting confused here. The weight of the titanium is about 1.7 times the weight of an equal volume of aluminum. The strength is less than 1.7 times at room temperatures. As the temperature of the material goes up the strength of the aluminum falls off at a faster rate than that of the titanium. So at temperatures above 300° the ratio of the strength of titanium to the density of it becomes better than that of aluminum.

Senator MALONE. But for the same strength titanium and aluminum at the same temperature below 300°, the titanium is heavier than the aluminum?

Mr. O'DONNELL. That is right.

Senator MALONE. Go ahead.

Mr. O'DONNELL. You have to generalize in these things. Some materials are designed for stiffness, and others are designed for strength. So the titanium columns and all might not follow in the same relation as the ultimate strength just mentioned.

Senator MALONE. Could you give us some idea how it does run in the columns for other shapes?

Mr. O'DONNELL. I have a series of reports, published by the National Committee on Aeronautics. Some are quite confusing because they cover a large amount of different types of aluminum, and also different types of titanium.

Senator MALONE. Different alloys?

Mr. O'DONNELL. Different alloys.

Senator MALONE. How do the titanium alloys compare in weight to the pure titanium?

Mr. O'DONNELL. The alloys are far better for the same weight. For example, the commercially pure titanium——

Senator MALONE. You have been talking about commercially pure titanium?

Mr. O'DONNELL. I started off, if you will recall, by saying we have two parts on the program. The first one is where we use the commercially pure titanium to take care of the fact that it is heat resistant and also it is hard. We make use of the alloys because we are taking care of the cases in which we are interested in the high strength at high temperatures.

Senator MALONE. But the cold strength in the titanium alloy is not as strong for the same weight as the aluminum?

Mr. O'DONNELL. That is right. There is a report here which might be of interest to the committee on the structural efficiencies. They have some generalized statements. I think they will be more important than the curves. It tells you about where it fits into the general picture.

Senator MALONE. It might be interesting to the committee, and it will be received as exhibit No. 1 with your testimony.

(The document above referred to was marked as "O'Donnell Exhibit No. 1," as follows:

EXHIBIT No. 1

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS—TECHNICAL NOTE 2975: STRUCTURAL EFFICIENCIES OF VARIOUS ALUMINUM, TITANIUM, AND STEEL ALLOYS AT ELEVATED TEMPERATURES

By George J. Heimerl and Philip J. Hughes, Langley Aeronautical Laboratory, Langley Field, Va.

SUMMARY

Efficient temperature ranges are indicated for 2 high-strength aluminum alloys, 2 titanium alloys, and 3 steels for some short-time compression-loading applications at elevated temperatures. Only the effects of constant temperatures and short exposure to temperature are considered, and creep is assumed not to be a factor. The structural-efficiency analysis is based upon preliminary results of short-time elevated-temperature compressive stress-strain tests of the materials. The analysis covers strength under uniaxial compression, elastic stiffness, column buckling, and the buckling of long plates in compression or in shear.

INTRODUCTION

At supersonic speeds, the effects of aerodynamic heating on the strength of aircraft or missiles must be taken into account. The behavior of the materials may prove critical either during transient or during steady heating conditions. The selection of materials having adequate strength under such conditions and at the same time providing a structure having minimum weight becomes a primary consideration.

The effects of steady rather than transient heating are considered herein. An attempt is made to give a general picture of the efficient temperature ranges for a few high-strength aluminum, titanium, and steel alloys for some short-time compresison-loading applications in which creep is assumed not to be a factor. The cases covered are strength under uniaxial compression, elastic stiffness, column buckling, and the buckling of long plates in compression or in shear. Some of the materials included, such as the titanium alloys RC–130A and RC–130B, the aluminum alloy XA78S–T6, and the steel Stainless W, are relatively new. The materials cover a wide range of strengths and densities, and the temperatures range up to 600° F. for the aluminum alloys, to 1,000° F. for the titanium alloys, and to 1,200° F. for the steels. The results are based upon tests of compression specimens taken from a single sample of each material and, consequently, should not be considered as necessarily representative. Besides materials previously mentioned, those included are extruded 75S–T6 aluminum alloy (data from ref. 1), the steel SAE 4340, and the heat-resistant nickel-base alloy Inconel X. For convenience in making general comparisons, Inconel X is grouped herein with the steels.

TESTS

In order to make the structural-efficiency comparisons for compression loading, compressive stress-strain tests were made. In these tests, the material was kept at test temperature approximately ½ hour before the load was slowly applied. The strain rate was maintained at about 0.002 inch per inch per minute during loading. Autographic stress-strain curves were obtained. The compressive test results for Young's modulus and the yield stress (0.2 percent offset) are given in table I along with information on the suppliers, heat treatments, and densities of the materials.

The test results for Young's modulus and the compressive yield stress are given in figures 1 and 2. In figure 1, the variation of Young's modulus with temperature T obtained for these materials is shown. At normal temperatures, the moduli vary from about 10×10^6 psi for the aluminum alloys to about 17×10^6 p. s. i. for the titanium alloys and to about 30×10^6 p. s. i. for the steels. The moduli for all the materials reduce with increase of temperature. The results for the new aluminum alloy XA78S–T6 are essentially the same as for extruded 75S–T6 aluminum alloy. The heat-resistant alloy Inconel X shows the least effect of temperature.

Figure 2 shows the variation of the compressive yield stress with temperature found for these same materials. The strengths range from about 80 k. s. i. for

the aluminum alloys to about 220 k. s. i. for the steels at normal temperatures. With the exception of Inconel X, a marked decrease in strength with increase in temperature is evident in all instances. The aluminum alloys, the titanium alloys, and two of the steels have lost about half of their normal strength at approximately 400° F., 800° F., and 850° F., respectively. Inconel X, a good high-temperature material, shows almost a negligible effect of temperature over the range covered. The results for the two aluminum alloys are essentially the same. Similarly, there is little difference between the titanium sheet and forging alloys. Above about 850° F., Inconel X is the strongest material.

STRUCTURAL EFFICIENCIES

From the results given in figures 1 and 2, together with the use of the stress-strain curves, various structural-efficiency comparisons can be made for the different materials. The comparisons which deal with compression loading are for strength, elastic stiffness, and column- and plate-buckling applications.

Strength efficiency.—In figure 3, the materials are compared on a strength-efficiency basis with the compressive yield stress taken as the criterion for strength. The stress-density ratio, which is equivalent to the load-weight ratio for a unit length of member, measures the efficiency of the material—the higher this ratio, the more efficient the material on a strength-weight basis. With the exception of Inconel X, all the materials are about equally efficient at normal temperatures. The steels and titanium alloys retain this efficiency much better than the aluminum alloys as the temperature increases. Stainless W and SAE 4340 appear to be somewhat more efficient than the titanium alloys RC–130A and RC–130B from about 300° F. to 800° F. Inconel X is the most efficient material above about 950° F.

Stiffness efficiency.—In figure 4, the materials are compared on the basis of elastic-stiffness efficiency. Inasmuch as the elastic stiffness of a material is given by Young's modulus, the stiffness efficiency is determined from the modulus-density ratio. Although there is a large spread in the results, the materials all have roughly the same efficiency at normal temperatures. The efficiency for the aluminum alloys, however, decreases rapidly with increase in temperature. At the higher temperatures, the steels are the most efficient, Inconel X being the most efficient material; the titanium alloys are next in order.

Column and plate buckling.—For column buckling and the buckling of long plates in compression or in shear, the structural efficiency for a material at a given temperature is found by a somewhat more complicated method by plotting calculated values of the buckling-stress—density ratio against corresponding values of an appropriate structural index. The method, which is described in reference 2, is based upon the use of the stress-strain curves for the material and covers both the elastic and plastic ranges. Rather than show all these curves for each material and temperature, comparisons are made over the temperature range only for a small and a large value of the index for each application.

The comparisons of the materials for column buckling are shown in figures 5 and 6 for small and large values of the column index $\frac{P_{cr}cf}{L^2}$. In this index, P_{cr} is the buckling load, c is the end fixity, f is the shape factor, and L is the column length. The efficiency is given by the stress-density ratio, the stress being the buckling stress associated with P_{cr}. Figure 5 is for a small value of the index $\left(\frac{P_{cr}cf}{L^2}=50 \text{ p. s. i.}\right)$, which corresponds to a small load or long column. The aluminum alloys are the most efficient up to about 300° F.; from about 300° F. to 900° F., the titanium alloy RC–130B is the most efficient; at still higher temperatures, Inconel X is the best. Figure 6, for a large value of the index $\left(\frac{P_{cr}cf}{L^2}=200 \text{ p. s. i.}\right)$ corresponding to a large load or short column, indicates quite a different comparison. In this case, with the exception of Inconel X, all the materials now have about the same order of efficiency up to about 300° F. From there up to 800° F., the titanium alloys RC–130A and RC–130B and the steels SAE 4340 and Stainless W have about the same efficiency; above about 950° F., Inconel X is the most efficient.

The efficiencies of the materials for plate buckling are compared in figures 7 and 8 in a similar manner for small and large values of the plate index $\frac{P_{cr}k^{1/2}}{b^2}$. In this index, P_{cr} is the buckling load, k is the plate-buckling coefficient, and b

is the plate width. The efficiency is again measured by the stress-density ratio, the stress being the buckling stress. Figure 7 is for a small value of this index $\left(\frac{P_{cr}k^{1/3}}{b^2}=4 \text{ k. s. i.}\right)$ which corresponds to a small load or wide plate. For plate buckling, the advantages of the lightweight materials are evident, the aluminum alloys being the most efficient up to about 450° F., and the titanium alloys from there up to about 1,000° F. Above 1,000° F., Inconel X is the most efficient. Figure 8, for a large value of the index $\left(\frac{P_{cr}k^{3/2}}{b^2}=8 \text{ k. s. i.}\right)$ corresponding to a large load or narrow plate, shows that the same order of efficiency still holds, although the efficient temperature range for the aluminum alloys is reduced to about 300° F. Inasmuch as both the efficiency and the index for shear loading are proportional to those for compression loading, the comparisons for plates loaded in compression also apply to plates loaded in shear (ref. 2).

General comparisons.—The results, which are summarized in figure 9, indicate in a general way the efficient temperature ranges and the order of efficiency of the materials for the various comparisons—compressive strength, elastic stiffness, column buckling, and plate buckling. For columns and plates, the letters A and B signify small and large loads, respectively. In this summary, the most efficient material for each of the classes of alloys is taken as the basis for comparisons. For each comparison, three bar graphs are shown: the first is for the aluminum alloys; the second, for the titanium alloys; and the third, for the steels. The order of efficiency for each material is indicated by the degree of crosshatching, the highest efficiency corresponding to the heaviest crosshatching as indicated. The following example illustrates the use of the figure. If elastic stiffness at 300° F. is under consideration, the third bar in the group shows that a steel is more efficient than a titanium alloy (the second one) which in turn is more efficient than the aluminum alloys. Without going into detail in the comparisons, it can be seen that the high-strength aluminum alloys are as efficient as or more efficient than the titanium or steel alloys for all applications except stiffness up to about 300° F. From about 300° F. to 950° F., the titanium alloys appear to be superior for plate buckling and equally or more efficient for column buckling; these alloys also compare well with steels for compressive strength up to about 900° F. The steels are the most efficient for elastic stiffness and equally or more efficient for compressive strength over the entire temperature range; they also are the most efficient above about 1,000° F. for column and plate buckling.

CONCLUDING REMARKS

The comparisons of two high-strength aluminum alloys, two titanium alloys, and three steels apply only to some short-time compression-loading applications under constant-temperature conditions and creep is assumed not to be a factor. The results, which are preliminary and based upon a limited number of tests, are subject to change depending upon the condition and treatment of the material. The comparisons are also incomplete in that no data are included for some magnesium alloys which at normal temperatures are very efficient for plate buckling or for 24S–T6 aluminum alloy which has definite advantages over 75S–T6 and XA78S–T6 aluminum alloys for elevated-temperature use. Without considering the creep aspects, the general indications are, however, that the aluminum alloys are equally or more efficient for compression-loading applications for temperatures up to about 300° F. From about 300° F. to 900° F., the titanium alloys look very promising. At still higher temperatures, a good high-temperature heat-resistant alloy is required to provide a structure having adequate strength and minimum weight. The final selection of a material for a particular application will also ordinarily depend upon many additional considerations.

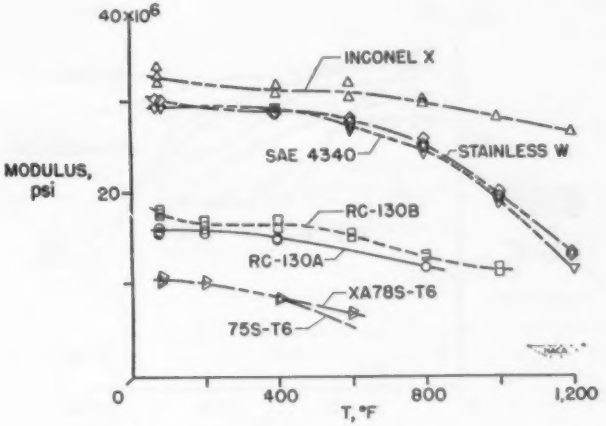
LANGLEY AERONAUTICAL LABORATORY,
National Advisory Committee for Aeronautics,
Langley Field, Va., May 21, 1953.

REFERENCES

1. Roberts, William M., and Heimerl, George J.: Elevated-Temperature Compressive Stress-Strain Data for 24S–T3 Aluminum-Alloy Sheet and Comparisons With Extruded 75S–T6 Aluminum Alloy. NACA TN 1837, 1949.
2. Heimerl, George J., and Barrett, Paul F.: A Structural-Efficiency Evaluation of Titanium at Normal and Elevated Temperatures. NACA TN 2269, 1951.

TABLE I.—*Description of materials*

Material	Designation	Received condition	Additional heat treatment	Source of material	Compressive properties and density at normal temperatures		
					Young's modulus, E. psi	Compressive yield stress, ksi	Density, Pound per cubic inch
Aluminum alloy extrusion	75S–T6	Heat treated by manufacturer.	None	Aluminum Co. of America	10.5×10^6	78.5	0.101
Aluminum alloy sheet (0.25 inch thick).	XA78S–T6	do	None	do	10.5	81.5	.01
Titanium alloy sheet (0.064 inch thick).	RC–130A	Cold rolled and annealed.	None	Rem-Cru Titanium, Inc.	16.2	140.8	.17
Titanium alloy forging	RC–130B	Annealed	Heated to 1,050° F. for ½ hour to remove machining effects.	do	17.7	152.5	.17
Steel sheet (0.064 inch thick)	Stainless W	Solution annealed	Precipitation hardening. Heated at 1,000° F. for ½ hour.	U. S. Steel Corp	30.2	220.0	.28
Heat-resistant nickel-base alloy sheet (0.064 inch thick)	Inconel	Annealed	Aged at 1,300° F. for 20 hours and air cooled.	do	32.9	115.0	.30
Steel sheet (0.064 inch thick)	SAE 4340	do	Heated at 1,525° F. for 10 minutes in controlled atmosphere; air cooled; drawn at 800° F. for 1 hour.	Crucible Steel Co. of America.	30.3	194.0	.283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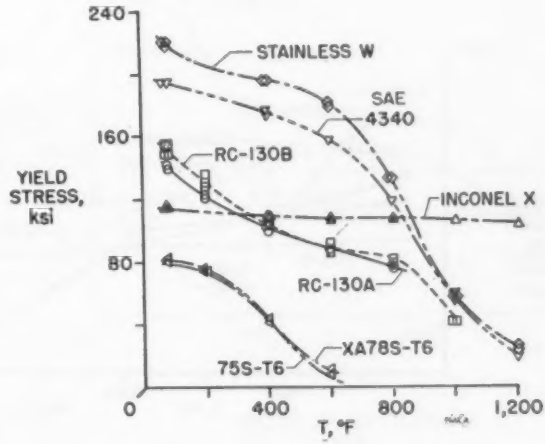
75S-T6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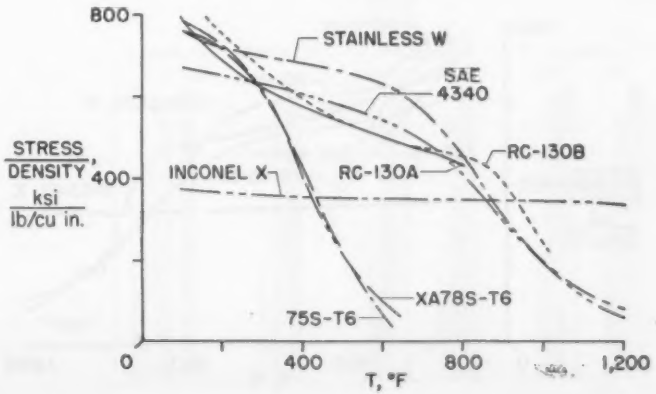
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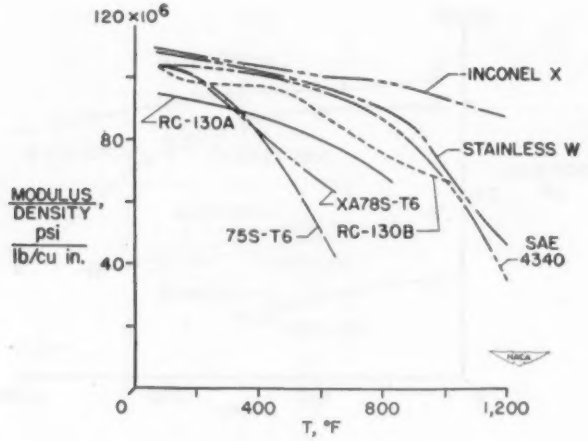
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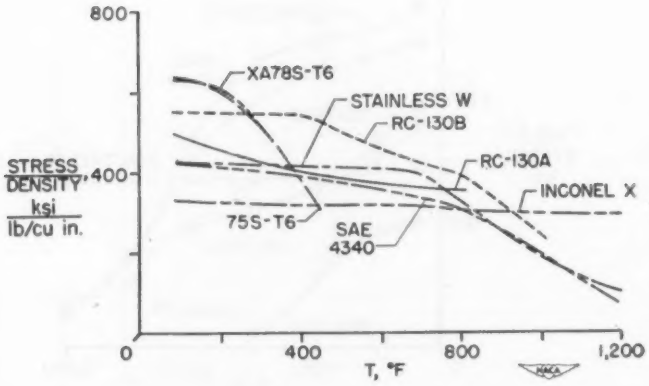
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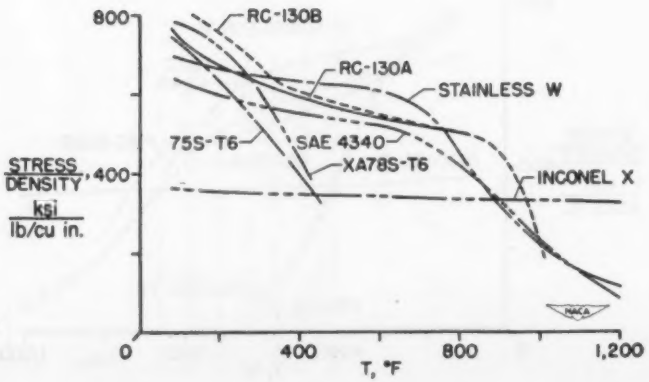
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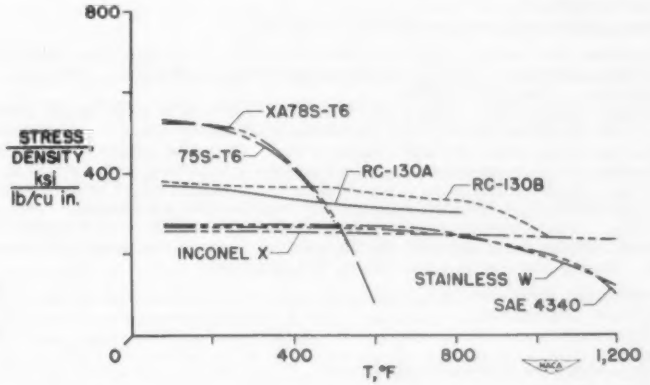
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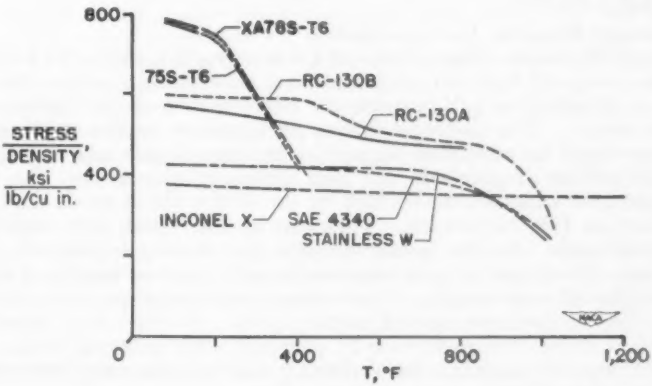
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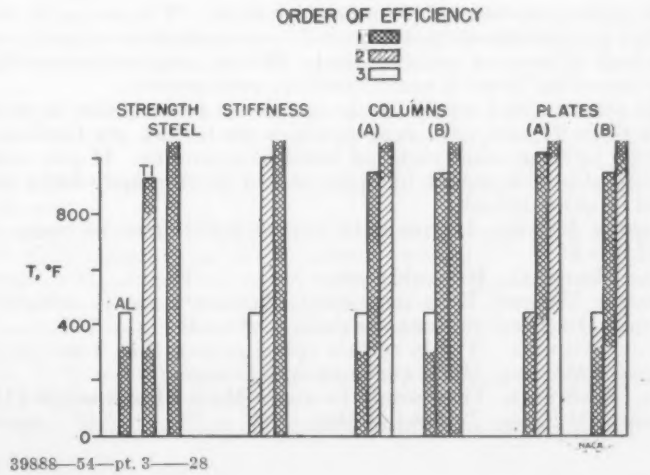
ORDER OF EFFICIENCY
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NACA TN 2975
National Advisory Committee for Aeronautics.

Structural Efficiencies of Various Aluminum, Titanium, and Steel Alloys at Elevated Temperatures. George J. Heimerl and Philip J. Hughes. July 1953. 16 p. diagrs., tab. (NACA TN 2975).

Efficient temperature ranges are indicated for two high-strength aluminum alloys, two titanium alloys, and three steels for some short-time compression-loading applications at elevated temperatures. Only the effects of constant temperatures and short exposure to temperature are considered, and creep is assumed not to be a factor. The structural efficiency analysis is based upon preliminary results of short-time elevated-temperature compressive stress-strain tests of the materials. The analysis covers strength under uniaxial compression, elastic stiffness, column buckling, and the buckling of long plates in compression or in shear. Copies obtainable from NACA, Washington.

1. Columns, Structural ---------- (4.3.1)
2. Plates, Structural ---------- (4.3.3)
3. Aluminum ---------- (5.1.1)
4. Steels ---------- (5.1.3)
5. Materials, Properties-Compressive ---------- (5.2.2)

I. Heimerl, George J.
II. Hughes, Philip J.
III. NACA TN 2975

Senator MALONE. Go right ahead.

Mr. O'DONNELL. The only point I was going to make is the fact that in the design of fighter-type planes that we specialize in we find that the use of titanium will improve the performance of the airplane to a great extent. The improvement in performance on the existing airplanes which we now have in production is not nearly as great as that which will be available in our next group of airplanes. The F–84 airplane, for example, we see that we can save without much change in production this 50 pounds. That can be converted into additional external loads. In the fighter bomber that is very important. The amount of load that an airplane can carry is more or less fixed by the total take-off gross weight. So it means you can convert directly into more load at the same take-off performance. Another way of looking at it is that you can go farther by carrying more external fuel. You would probably improve the radius of action in the neighborhood of 50 divided by 3 or so, about 16 or so miles.

In the case of the airplanes to replace the F–84F airplane, we plan to use approximately 400 pounds of titanium. The saving in weight on that is approximately 160 pounds over and above what it would have been if we used stainless steel. If that airplane were designed to go somewhat faster it again should be even greater.

The other point I would like to emphasize again is that in order to fly in these higher speed ranges, which we believe are feasible, you must go to some other material besides aluminum. If you went to stainless steel the weight increases would be extremely large and it would be quite difficult.

Senator MALONE. It would be rather prohibitive in some cases, would it not?

Mr. O'DONNELL. It would; yes.

Senator MALONE. Does that leave titanium metal practically the only metal to substitute for the metals now used?

Mr. O'DONNELL. Within certain speed ranges, that would be true.

Senator MALONE. What are those speed ranges?

Mr. O'DONNELL. They would be above Mach II and below III–½.

Senator MALONE. Tell us in miles.

Mr. O'DONNELL. We speak in terms of Mach numbers because it is more convenient. Above 1,200 miles an hour and below maybe around 2,500 miles per hour.

Senator MALONE. You no doubt noticed the newspaper reports, and maybe you know all the details, that on the west coast recently a pilot flew one of these experimental planes at 1,200 miles an hour?

Mr. O'DONNELL. Yes.

Senator MALONE. Do you agree with a good many authorities that some of these speeds that were anticipated several years ago as being rather theoretical will come about in a reasonable time?

Mr. O'DONNELL. We are quite firmly convinced that such things can be done in a fairly short time.

Senator MALONE. But the only way they can be done is to use this material we are now discussing?

Mr. O'DONNELL. That is right.

Senator MALONE. If that is a fact, then we come down to the next and vital question for the committee, if this is the only practical material within the ranges you suggest, and you think these ranges will be reached within a reasonable time, then how much titanium would you put in one of these planes?

Mr. O'DONNELL. We would build one of these very fast airplanes out of titanium mostly.

Senator MALONE. 40 percent?

Mr. O'DONNELL. 90.0 percent possibly.

Senator MALONE. What will this plane weigh?

Mr. O'DONNELL. Theorizing, and not referring to any particular design——

Senator MALONE. You are an expert.

Mr. O'DONNELL. Take a new fighter plane weighing 22,000 or 25,000 pounds combat weight, the structural weight would be probably around 13,000 pounds; so it would be something like 12,000 pounds per plane.

Senator MALONE. Of titanium?

Mr. O'DONNELL. Yes. That is in round numbers.

Senator MALONE. How many of these planes would we ordinarily be building?

Mr. O'DONNELL. We would like to build—I will put it that way—large numbers of airplanes. We built 15,000 P–47's during the war. That would give an indication of the numbers we would like to talk about.

Senator MALONE. That was the plane that was used as a fighter plane. I think we had those planes in Alaska when I was there in 1942.

Mr. O'DONNELL. That is right, sir. It is a single-engine airplane, single seat.

Senator MALONE. This plane that weighed the 13,000 pounds?

Mr. O'DONNELL. That is the structure weight.

Senator MALONE. That would mean how many pounds of titanium?

Mr. O'DONNELL. Probably 12,000 pounds.

Senator MALONE. And how many of these planes did you say you built, 15,000?

Mr. O'DONNELL. Yes; we made fifteen-thousand-three-hundred-some-odd airplanes.

Senator MALONE. That is a good deal of titanium.

Mr. O'DONNELL. That is right.

Senator MALONE. You would not make less in the next war. Somebody would be making them.

Mr. O'DONNELL. Yes.

Senator MALONE. What we are trying to get is some idea of the demand for titanium and the speeds you will have to reach if we are to survive. We still come back to the story of the cornstalk. A boy in the South and a boy from the North were arguing before the Civil War as to how you are going to win, and the southern boy said, "We will whip those northerners with cornstalks." It so happened that after the war was over they met again, and one said to the other, "I thought you could whip us with cornstalks." The reply was, "We could have but they would not fight with cornstalks."

If it is possible for us to make these airplanes, some other country can also make them.

Mr. O'DONNELL. That is right.

Senator MALONE. If they do that and we do not have them where does that leave us?

Mr. O'DONNELL. We will not do well in the next war.

Senator MALONE. We will have the second best poker hand.

Mr. O'DONNELL. That's right, and you can't win with one.

Senator MALONE. Besides, you are murdering our boys.

Mr. O'DONNELL. That is right.

TITANIUM REQUIREMENTS IN AN ALL-OUT EMERGENCY

Senator MALONE. Now let us get into this point. What titanium production do we need to enable us to be prepared for the next war? You are in the business.

Mr. O'DONNELL. We, of course, realize that the amount that is planned for the next few years is not sufficient. We have not been able to put it into our existing airplanes because it is not available. We also recognize the fact that we would like to go to these higher speed airplanes. We believe that the production should be very greatly increased. These are all general statements, of course.

Senator MALONE. How much? You heard about the 35,000 tons.

Mr. O'DONNELL. I think that is entirely too low. I go along with more than 100,000 tons.

Senator MALONE. General Metzger testified 2 or 3 months ago before this committee that we needed one hundred to one hundred and fifty thousand tons annually if the airplane manufacturers knew titanium was available.

Mr. O'DONNELL. That is right.

Senator MALONE. Now, apparently somebody had to break the ice. What the committee would like to know—and we do not want to put words in your mouth—is what we are going to do in the next war. Not just go out and get whipped, in other words. So if you had 30,000 of these planes, you would need twice as much titanium.

Mr. O'DONNELL. That is right.

Senator MALONE. Did not someone else make some fighters besides you?

Mr. O'DONNELL. Yes, Lockheed and North American.

Senator MALONE. How many fighters did you have in the war?

Mr. O'DONNELL. We apparently made the most, I believe. The other companies made about the same as a total together. I think it was 30,000 or 40,000.

Senator MALONE. And over what period?

Mr. O'DONNELL. That was made from 1941 until 1945.

Senator MALONE. In 4 years.

Mr. O'DONNELL. In 4 years.

Senator MALONE. Do you have any idea whether the next war will require less or more planes?

Mr. O'DONNELL. It is difficult to say. The planning now is for less. That is about all we can say. It is possible that because of the weapons we use we might get by with less.

Senator MALONE. That is very interesting.

General METZGER. Senator Malone, I am not quite clear personally on this one figure of 13,000 pounds structural weight. That is finished weight?

Mr. O'DONNELL. That is right.

SCRAP

General METZGER. How much titanium do you estimate it would require in metal form to produce 13,000 pounds of finished weight?

Mr. O'DONNELL. I believe in the beginning we are talking about an order of twice as much, or, in the first airplanes, three times as much, and then it gets down to twice as much. If we got into production similar to this it might be increased by about 50 percent. So it would be, roughly, 19,000 pounds or something like that. It was 12,000 pounds of finished titanium, so we should say 18,000 pounds per airplane in rough numbers.

Senator MALONE. That would account for the scrap?

Mr. O'DONNELL. Yes. And also you have to do a lot of machining.

General METZGER. I am sure, Senator Malone, that the committee will take into consideration the conversion factor of sponge, or to mill products, or sheet, or to metal, inasmuch as the committee is exploring the availability and production of sponge titanium. It might be well to consider if any figures or derivatives or extensions of these figures are calculated to use a further conversion factor to arrive at the sponge titanium requirement to support 12,000 pounds of finished weight in an aircraft.

Senator MALONE. Have you any figures in that regard, as to the amount of sponge that is necessary to go into the rolling mills to produce the 18,000 pounds of rolled mill?

Mr. O'DONNELL. The only information I have was the period for the future. I have some information, I believe, here which would give that.

Senator MALONE. Then, considering the scrap and the grinding, out of 18,000 pounds of finished sheet material you have 12,000 pounds in the plane?

Mr. O'DONNELL. That is right. Some of these numbers here might be of interest to you.

(NOTE.—Does not apply to sponge requirements.)

Senator MALONE. Do you have any tables that you would like to submit for the record?

Mr. O'DONNELL. I do not like to give these copies away at the moment.

Senator MALONE. They are scarce or classified?

Mr. O'DONNELL. They are scarce.

Mr. ADLERMAN. Could you have those photostated and have copies sent to us?

(Copies were not furnished in time to be included in the printed hearings. When received will be included in the committee's files.)

Mr. O'DONNELL. Yes.

Senator MALONE. Mr. Bradford, do you have any idea as to the loss from the conversion of sponge to the rolled finished material?

Mr. BRADFORD. Yes. Mr. Chairman, as I reported this morning, and in my writeup, our yields have run and are running between 60 and 65 percent, or one and a half times the finished fabricated forms would give you the quantity of sponge required. That is average for billets and sheet. Sheet is lower, billets are higher.

Senator MALONE. From the sheets if you required 12,000 pounds of material on a plane, then you have your scrap losses and conversion from the sheet to the material actually used amounting to how much loss?

Mr. BRADFORD. Mr. O'Donnell, I believe, said they would figure around initially 3 to 1 and 1½ to 1. I took 2 to 1 here and our factor of 1½ and you come out with 36,000 pounds of sponge required for the aircraft.

Mr. O'DONNELL. There is some scrap you can reuse.

Mr. BRADFORD. This is on the basis of present yields.

Senator MALONE. Mr. Gross, in his testimony, used a factor of 60 percent: 36,000 pounds of titanium sponge would actually make one plane of 12,000 pounds of titanium material.

Mr. BRADFORD. Based on Mr. O'Donnell's figures and today's yield.

Senator MALONE. Based on one-third?

Mr. BRADFORD. Yes, sir.

Senator MALONE. That is very clear. Mr. O'Donnell, do you have anything further?

Mr. O'DONNELL. No, I believe not.

Senator MALONE. Your testimony has been very helpful, and I hope if you have anything further to offer to the committee, you will just send us a letter or a short brief.

Mr. O'DONNELL. Yes, sir.

Senator MALONE. Thank you very much.

Mr. O'DONNELL. Thank you, Mr. Chairman.

Senator MALONE. Mr. John Ford of the General Services Administration. You were here this morning, were you not?

STATEMENT OF JOHN FORD, GENERAL SERVICES ADMINISTRATION, WASHINGTON, D. C.

Mr. FORD. Yes, sir.

Senator MALONE. You heard the objectives of the committee and you heard the testimony of the requirements, and I want to emphasize again that the committee wants to be helpful to you.

Mr. FORD. Surely.

TITANIUM REQUIREMENTS

Senator MALONE. Regardless of any estimates in the past or any errors that anyone may have made, there had to be something done, like in all new fields, and someone had to make the decisions. Most anyone can make a better estimate after they see how it works. That is not what the committee is trying to do. It is trying to find out whether it can be helpful, and the only way it can be helpful is to determine the real demand for this material, and then offer whatever encouragement it can to the production of that amount of material.

Could you give us, in view of the testimony this morning, some information to who makes and made the decisions as to requirements and the final decision as to how much should be contracted for, and, if you care to, what your feelings in the matter are now?

Mr. FORD. Senator, we get our requirements in the form of a program approved by the Office of Defense Mobilization, Dr. Flemming's organization.

Senator MALONE. That is the new organization that has taken charge of all of these other alphabetical agencies?

Mr. FORD. That is correct.

Senator MALONE. How many alphabetical agencies are funneled now into Mr. Flemming's organization?

Mr. FORD. That would be hard for me to answer.

Senator MALONE. I thought maybe you were familiar with it. I would be very much interested if you could give us a list.

Mr. FORD. As I recall it, Senator, I believe we supplied something of that sort after our October testimony.

Senator MALONE. I believe you did in the matter of stockpiling and the agencies mixed up with that stockpiling arrangement. How many were there? About 36 of them?

Mr. FORD. I think there were more than 36. I think there were almost 55.

Senator MALONE. They all had a hand in controlling the stockpile and the amount of orders of strategic materials.

Mr. FORD. They all had a piece of it.

FEDERAL AGENCIES INVOLVED WITH STOCKPILING

Senator MALONE. All of that 36 or 50 agencies are now centered in Mr. Flemming's organization, are they?

Mr. FORD. I believe that is correct. Mr. Flemming's Office of Defense Mobilization is the key agency on requirements.

Senator MALONE. Are these other agencies still active but submit their recommendations to Mr. Flemming, or are they abolished and he makes the decision himself?

Mr. FORD. A number of them have been abolished. The agency that had been approving the programs was the Defense Production Administration, and that was liquidated last spring, and its functions taken over by the Office of Defense Mobilization.

Senator MALONE. Who was at the head of the Defense Production Administration?

Mr. FORD. The last administrator was Mr. Fowler.

Senator MALONE. He disappeared before the Defense Production Administration disappeared, did he not?

Mr. FORD. I don't recall that to be the case, Senator. I think that the two events coincided.

Senator MALONE. Simultaneously?

Mr. FORD. Yes, sir.

Senator MALONE. I was just trying to determine who finances the contracts now after they are authorized or determined by Mr. Flemming.

Mr. FORD. Mr. Flemming's office, in the approval of projects or a group of projects for a specific commodity, also has the authority to allocate the borrowing authority provided under the Defense Production Act to finance these projects.

Senator MALONE. Under the Defense Production Act?

Mr. FORD. The Defense Production Act is Public Law 774, passed in 1950.

Senator MALONE. Who administers it?

Mr. FORD. The Office of Defense Mobilization administers that portion of it which applies to the production of material.

Senator MALONE. Do they handle the financing when they authorize the purchase of this material? Is that the end of it? There is no other organization that handles the actual financing?

Mr. FORD. No, sir. The General Services Administration, under the allocation of borrowing authority and the specification of requirements that is given by the Office of Defense Mobilization, then proceeds to negotiate these contracts and handle the commitment of funds to administer them.

Senator MALONE. Then there are just two agencies besides the Department of Defense itself, of which Mr. Wilson is the head. He deals with Mr. Flemming, and everyone deals with Mr. Flemming in determining the amounts necessary; is that right?

Mr. FORD. That is correct.

Senator MALONE. Then the General Services Administration takes over from there and has nothing to do with the amounts whatever but then furnishes the financing and enters into the contracts necessary to secure this material? Is that true?

Mr. FORD. I think I would say that the authority to handle the financing is also provided by the Office of Defense Mobilization.

Senator MALONE. Is there now a General Services Administration?

Mr. FORD. Yes, sir.

Senator MALONE. What is its function?

Mr. FORD. The General Services Administration is the agency that was established in 1949 to handle the procurement activities of the Government for nondefense matters and take care of public buildings and matters of that sort.

PROGRAM REQUIREMENTS AND PROCUREMENT

Senator MALONE. Do they finance the contracts now to secure national-defense material?

Mr. FORD. Yes, sir.

Senator MALONE. Did I misunderstand you when I thought you said that Mr. Flemming also makes these contracts?

Mr. FORD. I did not intend to say that. What I was trying to do, sir, was to say that the General Services Administration makes contracts for commodities in amounts that have been authorized by the

Office of Defense Mobilization, and it is also dependent on the Office of Defense Mobilization for the authority to borrow funds from the Treasury to administer these contracts and pay for any materials that are produced.

Senator MALONE. Let me see if I understand it now. First, Mr. Flemming acts, and if he says they want 2 tons of titanium or 200,000 tons of titanium, he authorizes that amount?

Mr. FORD. Yes, sir.

Senator MALONE. What is your title with this General Services Administration?

Mr. FORD. I am Chief of the Contract Branch.

Senator MALONE. Who is the head of it now?

Mr. FORD. Mr. Edmund F. Mansure.

Senator MALONE. Under Mr. Mansure, you make the contract for that amount of material; is that right?

Mr. FORD. Yes, sir.

Senator MALONE. Then after this contract is made you have to have the approval of Mr. Flemming, the head of this organization that you just mentioned, to secure the money to carry out the contract?

Mr. FORD. Not exactly. Mr. Flemming's authorization to draw the funds is given at the same time as he authorizes the contract for the material.

Senator MALONE. Then actually and practically there are two operations. One is Mr. Flemming determining the amount of the material and giving the authorization for the money necessary to carry it out, and you make the contracts to carry it out?

Mr. FORD. Yes, sir.

Senator MALONE. That is not so complicated as appeared from your first statement. There are just two of you in the deal, two organizations? Is that right?

Mr. FORD. That is right.

Senator MALONE. You take the place now of these 36 or 50 organizations that had a hand in it prior to this administration? Is that right?

Mr. FORD. Yes, sir.

Senator MALONE. Now, then, since we fixed the responsibility, it is then Mr. Flemming's decision on which you make contracts for 22,000 tons of titanium annually?

Mr. FORD. The figure is now 25,000, Senator. That is the figure that was fixed by the Office of Defense Mobilization.

Senator MALONE. When did he fix that figure?

Mr. FORD. During the summer. I think it was in July.

Senator MALONE. Was it not 22,000 prior to that time?

Mr. FORD. There was a figure of 22,000 that was fixed earlier in the year.

Senator MALONE. Was it 22,000 or 22,500?

Mr. FORD. It was 22,000, as I recall it.

Senator MALONE. Who fixed that amount?

Mr. FORD. Office of Defense Mobilization.

Senator MALONE. Mr. Flemming?

Mr. FORD. Yes.

Senator MALONE. He later raised it 3,000 tons annually?

Mr. FORD. That is correct.

Senator MALONE. Do you know anything about the reasons for raising the amount, or is that out of your field?

Mr. FORD. That is out of my field.

Senator MALONE. But it is now 25,000 tons?

Mr. FORD. That is correct.

QUANTITIES UNDER CONTRACT

Senator MALONE. How many tons have you contracted for?

Mr. FORD. Including the private facilities of Du Pont, the total amount is 13,200 tons per year.

Senator MALONE. Divided how?

Mr. FORD. That is divided 2,700 to Du Pont.

Senator MALONE. Per year?

Mr. FORD. Yes, per year; 3,600 tons per year to Titanium Metals Corp., and 6,000 tons per year to Cramet, Inc.

Senator MALONE. How many tons per day is that?

Mr. FORD. Thirty-six hundred tons per year is 10 tons per day.

Senator MALONE. And 6,000 tons per year is about 16 or 17 tons per day; 2,700 is of the order of 7½.

The committee did not know until today that you had only really contracted for 7½ tons per day. I do not think you made that clear before. It was considered a 10-ton-per-day contract. We find out today from the testimony of the company itself that they are already at 2½ tons production, and you merely contracted for an additional 7½ tons. That is true; is it not?

Mr. FORD. Yes, sir.

ACTUAL PRODUCTION

Senator MALONE. The committee has considerable trouble in getting this testimony straightened out. What is the status of these contracts? How much are they producing?

Mr. FORD. The only facilities that are now in production are the TMCA contract, the Titanium Metals Corp. contract. That is aside from the 2½-tons-per-day facility of the Du Pont people. Did you ask me how much was being produced?

Senator MALONE. All together, and who is producing it. As I understand you now, your testimony agrees with the Du Pont Corp., that they are producing the original 2½ tons per day with which you had nothing to do whatever.

Mr. FORD. That is right.

Senator MALONE. Therefore, there is no production under the Government contract at this time.

Mr. FORD. At du Pont?

Senator MALONE. That is right.

Mr. FORD. That is correct, sir.

Senator MALONE. Go ahead.

Mr. FORD. The Titanium Metals production was 348 tons through December 31, 1952. In the first quarter of 1953 they produced 234 tons; in the second quarter they produced 247 tons; in the third quarter they produced 298 tons. The total production from that facility is 1,127 tons.

Senator MALONE. What is the per day production during the third quarter?

Mr. FORD. During the third quarter?

Senator MALONE. Since you have it on a per-day-production basis, give it to us for the first, second, and third quarters.

Mr. FORD. Three and three-tenths tons per day.

Senator MALONE. For the third quarter?

Mr. FORD. Third quarter average; yes, sir.

Senator MALONE. What do you anticipate for the fourth quarter? Do you have an estimate?

Mr. FORD. I do not know whether I have an estimate here or not. It is my recollection that it was something on the order of 300 tons. It was not a large increase over the third quarter.

Senator MALONE. What would that be if it was 300 tons, on a per day basis? If it was 300 tons for the quarter what would it be for the day?

Mr. FORD. It would be just about the same, about 3⅓ tons per day.

Senator MALONE. When were they supposed to reach full production of 10 tons per day under the contract?

Mr. FORD. In September of 1952.

Senator MALONE. What is the matter with the production? What ails it?

QUALITY OF PRODUCTION

Mr. FORD. They have not been able to overcome some manufacturing difficulties that they have had in getting an acceptable quality production of sponge.

Senator MALONE. Do they have the necessary capacity if they could obtain the desired quality?

Mr. FORD. That has never been demonstrated.

Senator MALONE. What do they lack? Have you tried to analyze it; or gotten a report on it?

Mr. FORD. Yes, sir.

Senator MALONE. Give it to us.

Mr. FORD. We have gotten several reports on it. Apparently just the matter of increasing the production of titanium sponge from the pilot-plant stage to the full-scale commercial-size production in which they have run into one obstacle after another. In addition to that, at the time this contract was entered into, the specifications for this material were not as well defined as they are at present. They have been confronted with demands from users of the material for a lower Brinell than they originally anticipated.

Senator MALONE. In your contract?

Mr. FORD. Yes, sir. It is mentioned in our contract. They have had to adapt their process in order to meet these higher requirements.

Senator MALONE. That is very interesting. You have made a contract for a certain grade of titanium. What is that grade?

Mr. FORD. The original specification was for a hardness of 160 Rockwell A, which is the equivalent of 225 Brinell.

Senator MALONE. Have you made any attempt to change the specifications?

Mr. FORD. Yes, sir. The company has discussed that with us on a cooperative basis, and they are attempting to produce material that is substantially better than that from a hardness standpoint.

Senator MALONE. How much better?

Mr. FORD. They are aiming at material of not over 180.

Senator MALONE. On whose invitation?

Mr. FORD. It is a situation that carries its own incentive with it. That is what their customers require.

Senator MALONE. Suppose they delivered this 225 Brinell to you, does your contract require you to take it?

Mr. FORD. Our contract does not require us to take any material from them except amounts that they may tender instead of cash in repayment of the advance for the construction of the plant plus interest on the advance.

Senator MALONE. How much would they get a pound for it from you if they tendered it?

Mr. FORD. They would get the current market price of $5 per pound.

Senator MALONE. Then my question to you was this, Suppose they tendered it, then you would have to take it?

Mr. FORD. We would have to take it.

Senator MALONE. Then what kind of an understanding do you have with them, that they continue to produce about a third of their contract after 3 years?

Mr. FORD. The contract is about 2½ years old. They were not supposed to come into capacity production until September 1952.

Senator MALONE. They are about a year and a quarter overdue, probably.

Mr. FORD. That is correct.

Senator MALONE. What do you think the solution to this matter is? You heard the testimony about need, and still we coast along. Are you responsible for any of it?

Mr. FORD. I certainly do not think we have coasted along, Senator.

Senator MALONE. What would you call it?

Mr. FORD. We have constantly been in communication with the company, seeking ways and means to get a quality of production out there that meets industrial requirements.

Senator MALONE. How did you come to make a contract in the first place that does not meet industrial requirements?

Mr. FORD. Because at the time we made the contract to the extent we could determine industrial requirements, it did meet them.

Senator MALONE. Is this the same contract you made with Du Pont?

Mr. FORD. The terms of the contract are generally similar. The Du Pont contract was made later than this one.

Senator MALONE. How much later?

Mr. FORD. A year. By that time the specification requirements for this material were better known and a tighter specification was put in the contract.

Senator MALONE. How much tighter?

Mr. FORD. The Brinell requirement on du Pont is 203.

Senator MALONE. That still would not fulfill commercial needs in your judgment.

Mr. FORD. No, sir, but it did at that time.

Senator MALONE. You did not know at that time what the specifications of the commercial trade were going to be.

Mr. FORD. In 1953 I would say that is correct, we did not.

Senator MALONE. What is that quality of material that Du Pont is now making on their original 2½ tons?

Mr. FORD. Dr. Gee testified this morning that the average quality was 168.

Senator MALONE. Do you not know of your own knowledge?

Mr. FORD. No, sir. That is the production of the du Pont privately owned plant, and we depend on them for the information.

Senator MALONE. Did you not have that information?

Mr. FORD. I have heard it previously.

Senator MALONE. You had not communicated with them about it, or asked them anything about it yourself?

Mr. FORD. No, sir, we had not.

Senator MALONE. You have no knowledge now whether, with this additional 7½ tons, whether they will produce 168 Brinell hardness material and sell it to private industry, or whether they will produce 203 and sell it to you? Apparently they could not sell the 203 Brinnell hardness to industry, according to your prior testimony.

Mr. FORD. I do not think they would.

Senator MALONE. Then you will probably be in the market for quite a bit of this material later. Could not that happen to you?

Mr. FORD. We foresaw that the developments in the industry would probably result in a demand for a better quality product. At the time of working out the contract the only way that we could cope with that was to write into the contract that as further commercial experience is developed the specification requirements of this article may be modified by mutual agreement of the contractor and administrator.

Senator MALONE. That could be done by mutual agreement with respect to your contract with Titanium Corp. whether it was written in the contract or not.

Mr. FORD. That is correct. We are working toward that end with Titanium Metals Corp.

Senator MALONE. What is the status of it?

Mr. FORD. Frankly, we do not see that we have gotten very far with it because the Titanium Metals Corp. is not at capacity production at the moment, and we are working along with them to see what develops out there.

Senator MALONE. Do you think it would take another year ar two or three?

Mr. FORD. No, sir; I do not think that it will.

Senator MALONE. What would you estimate to be the length of time before they reach the specifications necessary and the capacity of production?

Mr. FORD. Three months, six at the outside.

Senator MALONE. They will be at capacity production?

Mr. FORD. Let me correct that. I was speaking about the working out of the contract, the changes in the contract. I think that capacity production is probably a minimum of 6 months off.

Senator MALONE. Capacity production at 180 Brindell hardness?

Mr. FORD. That is 10 tons a day with a hardness of 180 Brinell; yes, sir. I say that is a minimum of 6 months off.

Senator MALONE. Let us get at this from a different point of view. You have three contractors now, do you not? One is not in production at all. When are they coming into production?

Mr. FORD. Two are not in production on the Government contract, Senator.

Senator MALONE. It seems to me I did not get this information from you last time when I asked you about the contracts. You talked about a 10-ton-a-day contract. Was that someone else from your outfit?

Mr. FORD. I do not know that anyone else from my office talked about titanium, Senator.

Senator MALONE. I think you talked about a 10-ton-a-day contract with each one of these companies.

Mr. FORD. If I did it was an inadvertence because I knew they had this capacity of their own that existed before they got into this contract with us.

Senator MALONE. You also knew that Titanium Corp. at Henderson, Nev., was not anywhere near its capacity and was not a satisfactory product.

Mr. FORD. Yes, sir.

Senator MALONE. I did not hear that in the testimony. Sometimes I cannot think of all the questions, and we would like to have you give us information that would be helpful to the committee.

Mr. FORD. I am sorry if that information was not given to you, Senator. I understood that you had conducted hearings at Las Vegas before we were up here to testify, and I imagined that you were aware of it.

Senator MALONE. Yes. Let me ask you one more question. You have contracts with du Pont. You have contracts with Titanium Corp. You have a contract now with Cramet, Inc., and we know that the Crane Co. that owns Cramet is a fine company in its own field. What it knows about titanium remains to be seen.

We know, according to their own testimony and yours, the corporation in New Jersey is producing a very fine quality of titanium. Presuming when they go into production, the Government production would be just as good.

Mr. FORD. You refer to du Pont?

Senator MALONE. Yes.

Mr. FORD. Yes, sir.

Senator MALONE. Is there any provision in your contracts or understanding with you that there will be or is any exchange of information on this process, or do all of your contractees work independently and, presumably, one might be producing 55,000 tons of titanium perfectly and the other struggling along to make 10 tons a day? Is that the way you operate?

Mr. FORD. As far as I know, there is little, if any, exchange of information between the three of them.

Senator MALONE. Have you made any attempt to arrive at any understanding in that regard? It is a little expensive the way we are doing it now.

EXCHANGE OF INFORMATION BETWEEN THE PRODUCERS

Mr. FORD. I agree with that. I agree that it is expensive. As far as the exchange of information between the three of them is concerned, the policies of the individual companies govern that, and

there is nothing in any of our contracts that requires them to exchange information with each other.

Senator MALONE. You understand we are trying to build a record here to see what you are doing. The committee is not determining what the policy should be. For 100 years, I suppose, we have protected through patents an individual or a company that works out a patent and finances it itself. But you are furnishing the money, or a large amount of it, for this work. It is $15 million each, or $14,200,000 each. Do you mean that you furnish the money and still there is no exchange of information or no protection to the Government on any process that might be worked out with Government money?

Mr. FORD. We do have some protection in the contracts as to new patentable inventions in the course of performance under the contract.

Senator MALONE. What is that understanding?

Mr. FORD. The contract provides that, as to a new patentable invention that was developed in the performance of the contract, "the Government or its nominees may at any time on a nonexclusive royalty-free basis use the said patent or invention for production or construction under any contract to the extent which the United States Government is actually a purchasing party."

Senator MALONE. Any process, then, would in nowise be affected by your contract furnishing the $14.2 million in the new contract.

Mr. FORD. Not unless they turned the facilities back to us in satisfaction of the advance.

Senator MALONE. I do not see that would make any difference because they would not let you use their patent process anyway. How would that make any difference?

Mr. FORD. The contract also provides that "in the event the facilities are returned for operation by the Government the contractor agrees that the rights herein and above enumerated, together with patents and information owned or controlled by the contractor and necessary to the efficient and complete operation of the facilities, shall be made available to the Government on a royalty-free license basis."

Senator MALONE. There is no evidence that they are discovering any new, or that they need any new improvement in their additional facilities because they are making 168 Brinell hardness, according to your information, at the moment without any Government money.

Mr. FORD. I think that the only answer I can give you to that is that if they did not have some process that would work for making this titanium when they came into the deal we would not have given them the contract.

Senator MALONE. You gave one contract to the Titanium Corp., and it apparently cannot, or has not, met the production schedule.

Mr. FORD. They have not been able to yet; that is right.

Senator MALONE. How do you account for that? They did not have it when they came in. Of course, you knew that.

Mr. FORD. They produced material on a pilot-plant basis.

Senator MALONE. But that does not conform to your other statement, that they knew how to produce it, or you would not have given them the contract on this basis.

Mr. FORD. Then let me amend that to say that we were convinced that they knew how to produce.

Senator MALONE. That is better. So you are convinced now that there is nothing you can do about it except with their consent. In

other words, they can go right ahead and sell whatever they produce that does not meet Government specifications anywhere they want to sell it. Unless you get their consent you cannot change the contract. If they fulfill their contract at 225 you can be forced to buy it.

Mr. FORD. You are speaking of the Titanium Metals Corp.?

Senator MALONE. Yes.

Mr. FORD. No, sir. I do not think that is the case at all.

Senator MALONE. What is the case?

Mr. FORD. To begin with, we are only obliged to take material from Titanium Metals Corp. to the extent that we advanced money to them. In other words, they can repay the advance in material of a less than 225 Brinell instead of repaying it in cash.

Senator MALONE. How much do they get for it, $5 a pound?

Mr. FORD. Yes, sir.

Senator MALONE. If they produce a 225 hardness they can sell it to you at $5 a pound up to $14 or $15 million?

Mr. FORD. Up to the amount that was outstanding.

Senator MALONE. That is quite a considerable amount, is it not?

Mr. FORD. There is another factor that enters into it there. I don't think we are absolutely defenseless from the Government's standpoint because there was a commitment on the company's part, an obligation to be in production at the rate of 10 tons a day.

Senator MALONE. So you could cancel if you wanted to?

Mr. FORD. Yes, sir.

Senator MALONE. Supposing after the expiration of your 6-month estimate they have not improved the process as you think they should and they are not in production, what do you intend to do then?

Mr. FORD. I think that the action then would have to be predicated on what they can accomplish at that time and what our alternatives are. If the material was needed and we could not get large quantities of more satisfactory materials some place else, I think perhaps we would feel compelled to continue and try to get the thing worked out.

Senator MALONE. You know you need the material. Are you convinced that you need more than you are getting?

Mr. FORD. Thoroughly.

Senator MALONE. How much do you think you need after you have heard the evidence, or have you read any of it?

Mr. FORD. I will stick with the Air Force, and say 100,000 tons. They ought to know.

Senator MALONE. You have not even started, have you?

Mr. FORD. The amount that we have under contract now is only 13 percent of the 100,000 tons.

Senator MALONE. After 3 years.

Mr. FORD. When did the 3 years start?

Senator MALONE. When you let a contract to the Titanium Corp.

Mr. FORD. That contract is the end of July 1951. It is a little over 2 years.

Senator MALONE. It is only 3 or 4 months, one way or another. But it seems to some of us you have made very little progress. If you do not know what to do now, we would like to know who is responsible. Are you responsible or is Mr. Flemming responsible for the lack of production of the amount you are instructed to get?

Mr. FORD. Within the limitation of 25,000 tons, the 12,000-ton gap between the 25,000-ton authorization and what we have under contract is our responsibility.

Senator MALONE. You figure when you let a contract you are out from under. It does not make any difference what happens after that.

Mr. FORD. No, sir, that is definitely not our concept of the matter. We think we are very much in the picture until the plant is producing in accordance with the terms of the contract.

Senator MALONE. What is your next move? You have unlimited confidence that you are going to get everything that you ask for although it will be a year and a half or 2 years late. Let us suppose you do not get it and you can see in 2 or 3 months you are not going to get it, what do you do then? Do you know how to produce titanium? Will you get some of our engineers out of the Bureau of Mines who know something about it and try to insert some energy into this thing, or how would you go about it?

Mr. FORD. Are you speaking of the Titanium Metals contract?

Senator MALONE. That is one of them; yes.

Mr. FORD. That is already being done, Senator. There have been several consultations between the engineers from the Bureau of Mines and the Titanium Metals people in regard to their difficulties out there.

Senator MALONE. Recently?

Mr. FORD. Within a matter of the last 3 weeks.

Senator MALONE. Up to the time that we held the hearing there, there had been very little cooperation.

Mr. FORD. I understand that is the case.

Senator MALONE. Did you not know that before we held the hearing?

Mr. FORD. Yes, sir.

Senator MALONE. But you let it go a year.

Mr. FORD. It was the condition that existed.

Senator MALONE. For a year?

Mr. FORD. For a year.

Senator MALONE. And as bad as we need titanium. It just does not seem possible, but I suppose that is the way these Government operations have been conducted. Do you have any further statement?

Mr. FORD. No, sir.

Senator MALONE. Thank you. If you get any further information that you think would be helpful to the subcommittee we would appreciate it.

Mr. FORD. I would be glad to, Senator.

Senator MALONE. Thank you.

We will recess now until 9:30 in the morning, and we will try to complete our hearing then.

(Whereupon, at 5:50 p. m., the subcommittee recessed, to reconvene at 9:30 a. m., the following day.)

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STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

TUESDAY, NOVEMBER 24, 1953

UNITED STATES SENATE,
SUBCOMMITTEE ON MINERALS, MATERIALS,
AND FUEL ECONOMICS OF THE COMMITTEE
ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to recess, at 9:30 a. m., in the committee room, 224 Senate Office Building, Senator George W. Malone, Nevada, chairman of the subcommittee, presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee).

Present also: Jerome S. Adlerman, counsel to the subcommittee; George H. Holderer, subcommittee engineer.

Senator MALONE. The subcommittee will be in order.

Our first witness this morning will be General Metzger, of Wright Field, but first I want to say that the situation as far as yesterday's evidence is concerned seems to be, first, that titanium is a must in warplanes; and second, that it is a very desirable material, even at the present price, in commercial planes, and that at the present price the civilian market is probably great, but unknown, due to the fact that there is no titanium available.

The committee has given this important metal about all the time it can afford to give it, because it has 77 other materials in the critical field, and Senate Resolution 143 directed the committee to determine their availability in time of war, and for our expanding economy, and for our security.

Next Monday we are starting the petroleum hearings, which will probably last most of the week. We are doing about the same thing in petroleum as in titanium. We find we are getting most of the rutile from Australia for titanium, and we are becoming dependent on India for illmenite.

From all the evidence the committee can secure, it is about the fourth most plentiful metallic mineral that occurs in the earth's surface, and there is no lack of deposits in this country and in Canada. Whether it is a plan to make us dependent on foreign shores across one or both major oceans for the things that you cannot fight without remains to be decided by the committee after all of the evidence is in.

We find that the Air Force, through General Metzger, has said—and I intend that he shall be the first witness this morning—that we need from one hundred to one hundred and fifty thousand tons of titanium

per year under present conditions for warplanes, and the evidence from the airplane companies is the same; Mr. Douglas, of Douglas Aircraft, Robert Gross, of Lockheed, two outstanding men in the profession, beyond whom it is not necessary for any Government outfit to go to learn how to make planes, in the opinion of the chairman of the committee, at least, and the Boeing Aircraft Co., and many lesser organizations.

The summation of all that testimony was that the general is substantially correct that in our preparation for this next war we will need titanium. You can pick up any paper, and there will be at least three columns devoted to our danger. If we did get into war and needed anything like the number of planes that we made in World War II, we would be getting into four, five, or six hundred thousand tons a year of titanium, if it were available, so they could take the planes off the board, just like they can with steel and aluminum and magnesium at the present time.

We find all this information that must have been available to all of Washington. How it could have escaped for several years the notice of the men responsible for securing these materials is a little difficult to understand, but a new organization has taken this responsibility over, and it seems that now is the time to reexamine the record. All of that information, however, has been available to everybody.

We took the trouble to inquire from anyone who knew anything about making planes and anyone who knew anything about how to use a fighting plane. However, they recommended 35,000 tons of titanium to be manufactured. They did not say when, apparently.

Finally, 22,000 tons were authorized, and 13,000 tons annually have been contracted for. About 2,200 tons are being made after 2½ years.

As the chairman of this subcommittee has often said, and will say again at this moment, it is not a committee intended to injure anyone. We want to be helpful. The committee needs your help to get this information for the United States Senate.

Some of the information we have received has deeply concerned me. It does not look very good. Congress passed the stockpile bill in 1946, and supplemented it by other acts subsequently, and we found that the contracts made by the stockpile people and the Mutual Security and ECA and all the other alphabetical agencies pay more for foreign material than they pay the domestic producer, and then complain that we are running out of ore in this country.

No one I ever met who claims to be a military strategist thinks you are going to get very many freight ships across either ocean after the fourth world war starts. If we continue to fight like in Korea, and not hit the enemy hard enough to make them mad, you can feed an army across one of these oceans. Maybe you can get ilmenite from India and rutile from Australia. The chairman has been in a good many different kinds of fights, but he has never been able to fight one that way.

AVAILABILITY IN WARTIME

What we want to know in this committee is the availability of these materials in wartime. That is what we intend to find out.

I have asked Mr. Mansure to be here this morning, and he is here, and he will follow the general. I am not going to ask him many questions. I do not think I will need to. I want to find out the status

of this business. I am sure that he will find out for the committee and will make it available without intricate questioning and investigation. Apparently all the General Services organization has done in the matter of getting this material is to let a contract, and then just keep up with the social life in Washington, and let it take its course. That would be my general conclusion up to now.

General, you have been present at every hearing the committee has held, and I have looked upon you as an adviser as I would like to look upon other Government officials. I am only speaking for myself as one member of the committee. One of our members is in Europe and others have other important work to do, and they expect a very clear and concise record; so it will not be any great job for them to become familiar with the facts that we are able to secure. I am going to ask you this morning, after hearing all the testimony, starting at Henderson, Nev., where a 10-ton-per-day contract was let 2½ years ago, now producing about 3½ tons a day, part of which meets specifications. You heard the testimony in Los Angeles of the men who are spending their lives in not only trying to make commercial planes in peacetime but trying to do what you want them to do in wartime or preparation for war; you yourself are in charge of the greatest field of its kind in the world, Wright Air Field, where the Air Force and the armed services carry out their experiments and determine what is needed. I am going to ask you to get the committee back on the track this morning.

Will you sum up, then, some of the evidence you have heard and give us your advice as to how we should proceed to get what you want?

We are trying to help you. If I did not figure that the committee could be helpful to the armed service and to the civilian population, I would not be interested in continuing the work.

General Metzger, you have been identified before for the committee; but will you give the reporter your title, full name, and give us your good advice this morning?

FURTHER STATEMENT OF BRIG. GEN. KERN D. METZGER, USAF, CHIEF, PRODUCTION AND RESOURCES DIVISION, AIR MATERIEL COMMAND, WRIGHT-PATTERSON AIR FORCE BASE, DAYTON, OHIO

General METZGER. I am Brig. Gen. Kern D. Metzger, Chief, Production and Resources Division, Air Materiel Command.

Among my responsibilities I have the responsibility of planning for the materials required and essential to produce the aircraft and weapons for the Air Force under any current production program; also to plan for those materials for mobilization objectives, should mobilization ever be directed.

I have testified, as Senator Malone stated, several times with respect to the Air Force interest in titanium. I would like to restate the Air Force interest very briefly.

Titanium has properties, particularly very favorable strength-weight ratios under elevated temperatures, which make it a most desirable, and I would like to say essential, metal for the Air Force—and in speaking of the Air Force I would like also to speak of the Bureau

of Aeronautics, the Navy air arm—if that combined air force is to be the best air force in the world.

As Senator Malone has so well put it in the past, a second-best air force is no air force at all. We want the best combined airpower, and I am sure that most people agree it is essential to the security of this country.

TITANIUM ESSENTIAL

Titanium is essential to the best airpower and the strongest airpower in the world, in my opinion, and essential in large quantities.

The Air Force has a secondary interest, and it could be as important as the first; that is, the ores from which titanium is presently produced are available in large quantities within the continental boundaries of the North American Continent. To produce the titanium required in support of a mobilization effort we need not go offshore and import under most unfavorable conditions in the event of war the ores necessary to produce the metal.

As has been pointed out, titanium ores are the fourth most plentiful in the crust of the earth. So the supply is readily available, that is, the supply during war.

The essentiality in support of airpower has been clearly established, in my opinion, by testimony of the aircraft manufacturers, by certain engine manufacturers, and other engine manufactures will testify today. I have every reason to believe that their testimony will confirm what has been previously heard by the committee.

The question of requirements has been batted back and forth at many meetings, and the figure of 35,000 tons annually is on record, placed on record by the Department of Defense, as a requirement which must be fulfilled at this point. Only a portion of it has been placed under contract, as stated by Senator Malone.

This question of requirements can be very misleading, Senator, in that requirements very generally follow availability. Even though it is recognized by all that a requirement does exist, it is just good business that a producer of airframes or of engines not design any material into his product which is not in ample supply or which he may not have reason to believe will be available to him to meet his scheduled commitments.

Senator MALONE. Was it not testified by the airplane makers that they have these planes on the board, but they cannot take them off the board until they have assurance of the availability of material?

General METZGER. That is correct, Senator, and that is the point I am pressing at this moment. We know that the 35,000-ton requirement which was submitted by the Department of Defense to ODM some years ago did not begin to reflect the actual requirements which is in existence. We know that many of our manufacturers of air weapons have not even had sufficient material or metal, or have been able to secure it, to engage in research and research processing to provide them with the judgment as to whether or not the application is beneficial. Until that time, until such research can be undertaken with availability of sufficient quantities of the material in good quality, a manufacturer is unable to determine the amount he would use or require for any given product. That is just elementary.

That has been the situation, so what we have been talking about pretty generally when we talked about 35,000 tons is that amount of

research and those requirements which have been developed through research with a very small supply of titanium material, and pretty generally up until the last few months of an inferior, unsatisfactory quality. Yet we have been unable, even under those conditions, to see at this point that the 35,000 tons annual production will be forthcoming within a year or 2 or 3 or 5. Only 13,800 tons has actually been put under contract.

Senator MALONE. How much of that 13,500 tons is in actual production?

General METZGER. There are two manufacturers or producers of titanium in production. I believe the production at present is around 2,000 tons per year.

Senator MALONE. General, Mr. Mansure is here. He will only take a few minutes, and has to go to another meeting. Would you mind allowing him to testify right now?

General METZGER. No, sir.

Senator MALONE. Is Mr. Mansure here?

Mr. Mansure, we are glad to see you. As a matter of fact, you are overdue for a visit. I am sorry we have not had it up to now. You probably heard my opening statement, in which I stated that out of the 35,000 tons of titanium that the national-defense organization says is necessary, 22,000 tons have been authorized, or a little more than 13,000 tons have been let, and about 2,000 tons are being produced.

You have just come into a new and very difficult job, and there is no blame on anyone being placed by this committee. What we are trying to do is to find out what the actual situation is in each one of these materials, what is being done about it, and all of that is very important. But the most important thing is what we intend to do about it, and what the committee can report to the United States Senate.

This just happened to develop into one of the most important materials because, as the general just said, because an air squardon in a fight is a good deal like a poker hand; there is no second best one very long. If we are going to get into a war or if we are going to prevent one—a good many people believe that if we were ready to take charge of the air over any portion of the earth's surface, that is important to us, and we have agencies set up to determine what those areas are, we probably would not even have a war, but we can stagger into one very easily if we keep on the way we are—Mr. Mansure, we have called you this morning because it has been very hard to get any information from your organization that is satisfactory. If you would like to make a statement, will you identify yourself for the purposes of the committee, and give us the benefit of any advice you have been able to acquire.

STATEMENT OF EDMUND F. MANSURE, ADMINISTRATOR, GENERAL SERVICES ADMINISTRATION, WASHINGTON, D. C.

Mr. MANSURE. I appreciate very much the opportunity to be here. My name is Edmund F. Mansure, Administrator of General Services.

I appreciate, General Metzger, your letting me come in. I have a very important board meeting I have to attend, and I will be very brief.

First of all, I just wanted to explain how we go about this. The Defense Department draws up their requirements, as you know, general, and then they advise ODM.

Senator MALONE. You are a member of ODM?

Mr. MANSURE. I sit on the Defense Mobilization Board, which advises the Director of the Office of Defense Mobilization. I am going to that board meeting from here. They review the requirements for defense, and the Director of the Office of Defense Mobilization, with the advice of the Board, directs the Emergency Procurement Service, which is a division of GSA, to obtain whatever the material happens to be.

Senator MALONE. And whatever amount they themselves determine is necessary?

Mr. MANSURE. Yes.

Senator MALONE. What do they base that on?

Mr. MANSURE. They base that on requirements submitted by the Department of Defense, and they review what defense feels they need.

Senator MALONE. But if the national defense recommends 35,000 tons of titanium, upon what would they base their information that they only need 22,000?

Mr. MANSURE. I did not sit in on that meeting, so I do not know. This is the first I have heard the 22,000 figure. I suppose that is reviewed by various people from defense, either the Secretary or the Assistant Secretary.

Senator MALONE. You mean people in defense that are higher than the people who originally recommended in defense?

Mr. MANSURE. Yes.

Senator MALONE. Would not Mr. Wilson be the one to send down the recommendation?

Mr. MANSURE. Possibly Charles Thomas, who is in charge of supply and logistics. I have never sat in on the defense meeting, but they probably met and reviewed it as a board or as a group rather than individually, and then advised the Secretary.

Then after the quantity to be obtained is found, the Emergency Procurement, formerly the Defense Materials Procurement Administration, actually does the buying.

As you know, by Executive Order the President merged DMPA into GSA. We now have the Materials Division of EPS and GSA handling the whole program. Why I gave you the background on that is that we are bringing the whole thing together into a unit to simplify the operation.

Senator MALONE. We did understand there were about 50 agencies like that.

Mr. MANSURE. All you have to look to now is EPS, Emergency Procurement, under Commissioner Walsh. Unfortunately he is on leave over this holiday, but he will be available the first of the week. The actual tonnage that we have received to date is only approximately 1,127 tons. It is not 2,000. We are shooting for 2,000 now.

Senator MALONE. Over what period?

Mr. MANSURE. That is what we have obtained for general industrial use to date.

Senator MALONE. Altogether?

Mr. MANSURE. Yes. That is an approximate figure.

Senator MALONE. What we had in mind on the 2,000 tons is the rate of production now is about 2,000 tons.

Mr. MANSURE. Yes.

Senator MALONE. Where it should be 22,000 even according to ODM.

Mr. MANSURE. We have 1 supplier to the Government, and we have 2 other suppliers under contract who are not yet in production.

Senator MALONE. Who are they?

Mr. MANSURE. I do not know them by name.

Senator MALONE. It is the Crane Co., to which you have let a 15-ton-per-day contract.

Mr. MANSURE. Approximately; yes.

Senator MALONE. You just let that contract.

Mr. MANSURE. Yes.

Senator MALONE. We also understood that contract was on somebody's desk up there for about a year before it was acted upon.

Mr. MANSURE. That might have been. I would like to explain that very quickly. First of all, I am not an expert in this field at all, but I do know the organizational management phase of it, and we can get at that in a hurry.

The first I knew of this was when you talked to me this morning, so I had no time to get any information. But I will say this, that John Ford, who was here yesterday, is available, and is back here in the room today and can give you the information you wanted yesterday.

Senator MALONE. We will have you back whenever you feel you are ready to testify.

Mr. MANSURE. He can supply you with the information that you wanted yesterday. What happened was that he received this phone call Friday and did not understand what information you wanted. Some of the information, of course, is classified, and that will have to be given to you in executive session.

In DMPA we were unfortunate in losing two Deputy Directors within a period of a very short time. We lost Howard Young at the end of May and then Tom Lyon in July.

Senator MALONE. How long had they been with you?

Mr. MANSURE. I believe Howard Young was with DMPA since its beginning in 1950.

Senator MALONE. That is the period we are complaining about, so I think you better make a new start.

Mr. MANSURE. That has been done already. We will have all of this information that you want available in the first part of the week, and we will have it tabulated so you can see just exactly the procedure and where we stand. I do not want to give you half information now, and then after we get all of the data together find out that some of that was wrong.

Senator MALONE. Let me make my position clear. This morning I did not think you would have any information with you because you have just taken over your job and getting your feet on the ground. I thought you ought to meet some of your employees and find out what they have been telling us or what they have not told us.

Mr. MANSURE. Surely.

Senator MALONE. What we are particularly interested in is why you do not follow through after you let a contract, and when it is

obvious that they are not producing. What do you do about it, for instance? None of the people that you have mentioned, as far as I know, know any more about titanium production than I do.

Mr. MANSURE. I think it is partly because it is a new metal and it is something we have to get into.

Senator MALONE. I can mention a couple of men to you who are already working for the Government out in the Boulder City Bureau of Mines. If you want one of them to fly back here, he will give you the picture pretty quickly.

Mr. MANSURE. That would be very helpful.

Senator MALONE. As far as the testimony shows, no one that knew anything about how to make titanium has ever been called upon in your organization.

COMPENSATION PROMISED

Mr. MANSURE. That is inexcusable and we will see that it is done. That will be changed quickly. I think even this short period this morning has been very helpful to me, because I have for the first time heard a definite statement from you, General, as to our minimum requirements. So we can start in from there, and see just what the possibility is of even hitting the minimum, let alone what you would like to have.

I would also like to have from you, Senator Malone, if I could, the names of these people that are helpful on background.

Senator MALONE. Dr. Wartman of the Bureau of Mines is a scientist. He is at the Bureau of Mines at Boulder City. We will supply the name of the man who is Director of the bureau there, and who is very much interested in it. Dr. Wartman, who uncovered the missing link in the production of titanium, really made production possible. I think he is entirely familiar with the operation that is going on out there. For your information, no one I met is very well satisfied with it. The only organization that I have had to deal with that did not seem to know anything about it was your organization. That is the reason I asked you to come this morning.

Mr. MANSURE. I am glad you talked to me about it, because you will find out that we will supply the information you need.

Senator MALONE. I knew you were not to blame. I do not want to place any of the blame on your help. It is a question of being helpful to you if you are the organization responsible for it, but we cannot be helpful to you unless we know what you are doing about it.

Mr. MANSURE. That is correct. I might just say this, that I would like John Ford to supply you with the information that he has.

Senator MALONE. I would rather receive it direct from you and let Mr. Ford work for you.

Mr. MANSURE. We will have it the first part of next week. Will you be in town next week?

Senator MALONE. Yes. You can just mail it to me at the Senate Office Building, and let us know the exact status of these contracts. As we understand the du Pont contract, they are not supposed to start the production under the contract until the middle of next year. Apparently the material they have been producing is very satisfactory. The specifications have been fulfilled in their private plant with which you had no connection at all. Very little, apparently, of the

production which you are responsible for has met specifications and the specifications themselves are unsatisfactory that your organization worked out to start with. You understand this was a new metal. Perhaps the information was not well known. We are still not blaming your organization. But unless we can get the information as to what you are now doing about it, I cannot tell you what the recommendations are going to be. I know you will get it for us. I know your background and I know you want to do a job.

Mr. MANSURE. I appreciate that very much. I might say, General Metzger, you could be very helpful with the information and knowledge you have on the overall subject if we could have closer coordination between Defense and ourselves. I think we are taking too many committees to go through.

General METZGER. I agree.

Mr. MANSURE. I do not mean by that that we want to go over or around anyone, but I feel if you know that something should be done, if you could have someone in Defense that could clear with us immediately, we could save a lot of time. We would like to have that experience and knowledge and background that you have or that people you are in contact with have. It would clear through the proper channels, but I would like to have it done more quickly and more directly if we could.

General METZGER. I would like to discuss that matter with you at your convenience.

Mr. MANSURE. I will be available at any time. If you have to go back, if you leave word with anyone in Defense I will be available.

General METZGER. Fine.

Senator MALONE. Then, Mr. Mansure, one other thing, and right on the point you mentioned, that you go through too many committees. We had men testifying here yesterday——

Mr. MANSURE. Not only committees, but people.

Senator MALONE. And too many of them know nothing about what they are doing, if you will pardon my way of putting it. We have little time to get going on this stuff from the information that we have received. We had a witness here yesterday, Mr. Garrett, of the Defense Department, that they have a committee of about 500 civilians—I am sorry I do not have the testimony here, but it is available to you—and that all of these men are experts in something, and they pick out the experts in the particular thing they want and they take about a year to make up their minds. Then it comes back and it goes here to there. I have been coming back here to Washington since 1927, when we were building Boulder Dam, Hoover Dam, and if there is anything that can get lost quicker in going from department to department and committee to committee, if there is any place in the world it could get lost quicker, I do not know where it would be.

Mr. MANSURE. Very good.

Senator MALONE. I think you are doing fine work to get rid of all these alphabetical agencies. I do intend to introduce a bill to make it a penitentiary offense if anybody uses initials instead of calling the agency by name. You are going to a meeting where you will decide these things, and I think this evidence that we are securing will be helpful.

Mr. MANSURE. I can be very helpful in explaining your position to that group.

Senator MALONE. It would not be my position. It would be the evidence. The evidence is that you need 100,000 tons of this material annually immediately. If you are figuring on a war, which as I say every headline keeps the taxpayers all worked up that they are going to get into one, you may need 4 and 5 and 6 times that much.

What we are doing, then, is fooling around with 22,000 tons, which is a little vague to me. I might add only 13,000 tons have been let. I know there are a lot of things that are going on in Washington that your organization has to be kept up in order to be well known and well liked, but I do not think you are the kind of man that has to do that.

Mr. MANSURE. No, and furthermore, regardless of the various activities that GSA gets into, that is a specific job we have to do and we have a specific part of GSA to handle that.

Senator MALONE. You are not responsible for getting any more than 22,000 tons, except you are a member of the board that cut that down.

Mr. MANSURE. No, I want to explain that. We sit in on the review of the overall problem, but I was not in on the titanium meeting. Now that I have this background my position would be entirely different. Just getting the general's views has been most helpful to me.

Senator MALONE. I think the general would be very helpful to your board if you called him down there. The reason I asked you why it was cut, they were rationing everything at one time, including potatoes, and they just ran out of potatoes and then they got so many they did not know what to do with them. There is no reason for a shortage of titanium. The ilmenite is so plentiful that you stumble over it even in Nevada. There is no scarcity of ilmenite. You do not have to get it from Australia and India. If you let the contracts, it will be made. I am of the opinion from the evidence that we now have it will meet any reasonable specifications required by industry. So I should say it should have top priority. There is no scarcity of material. That is not any excuse. It is a question of whether you want to make it or not.

I do not want to advise your board, but if you have any skepticism about the information in these hearings, Mr. Gross and Mr. Douglas, and the Boeing Aircraft people, and all, I am sure would be available to you.

Mr. MANSURE. I know they are outstanding, and just what you have said is sufficient for us to form our judgment and opinion on it.

Senator MALONE. Then could you address a communication to the chairman of the subcommittee at your earliest convenience and give us all of this information?

Mr. MANSURE. We will have that this coming week.

Senator MALONE. Thank you.

Mr. MANSURE. I appreciate being able to leave in time to attend the meeting I mentioned.

(The following letter was later received for the record:)

GENERAL SERVICES ADMINISTRATION,
Washington, D. C., December 7, 1953.

Hon. GEORGE W. MALONE,
Chairman, Interior and Insular Affairs Committee,
Senate Office Building, Washington, D. C.

DEAR SENATOR MALONE: There follows an outline of the activities of General Services Administration and its predecessor agencies directed toward increasing the availability of titanium metal for defense and industrial uses.

TITANIUM PROGRAM

Authority to expand capacity for titanium production stems from the provisions of the Defense Production Act of 1950 (Public Law 774, 81st Cong.) as amended and Executive orders issued thereunder. General Services Administration operates within limits as to amounts of production prescribed by Office of Defense Mobilization and its predecessor, Defense Production Administration. Funds to administer such undertakings are authorized by Office of Defense Mobilization in accordance with the borrowing authority provided in the act.

(*a*) On July 18, 1951, Defense Production Administration issued a certificate to the General Services Administrator as to the necessity for a contract with Titanium Metals Corp. to provide for an annual production of 3,600 tons of titanium sponge. This carried with it borrowing authority for $15,000,000.

(*b*) A further authorization was issued by Defense Production Administration August 22, 1951. This provided for a program extending until March 15, 1952, for the purchase and resale of 1 million pounds of titanium and allocated borrowing authority of $5 million. The objective of this certification was to absorb production from the E. I. du Pont de Nemours & Co. plant which was not purchased by industrial users, holding it until such time as industry could use it.

(*c*) On May 22, 1952, the Defense Production Administration certified the necessity of a contract with E. I. du Pont de Nemours & Co. to increase its existing productive capacity of 900 tons per year to a total of 3,600 tons per year. Borrowing authority of $14,700,000 was allocated.

(*d*) On August 25, 1952, the Defense Materials Procurement Agency submitted a recommendation to Defense Production Administration requesting approval of a program for the annual production of 35,000 tons of titanium sponge and the certification of a total borrowing authority (including amounts previously authorized) of $194,700,000. On October 16, 1952, Defense Production Administration authorized an expansion goal of 22,000 short tons and the aggregate amount of $128,700,000 borrowing authority which included $25 million to be utilized in process development.

Subsequently, on March 27, 1953, a general freeze on all expansion projects was imposed by the Office of Defense Mobilization. As a result of an exchange of correspondence between the Director of the Office of Defense Mobilization and the Munitions Board in April 1953, the Office of Defense Mobilization reaffirmed its previous position certifying a program of 22,000 tons but authorizing the negotiation for an additional 3,000 tons subject to review by the Office of Defense Mobilization. This is the current program.

Defense Materials Procurement Agency was instructed to make a study of the various methods of producing titanium, including costs and time factors, and to submit recommendations to Office of Defense Mobilization regarding policies that should be adopted to achieve the 35,000-ton level with minimum financial risk to the Government.

Because of the difficulty in attaining production under the Titanium Metals Corp. contract and consequent inability to place a second contract for 5,400 tons with that organization, General Services Administration, which succeeded Defense Materials Procurement Agency on August 14, 1953, again recommended on October 26, 1953, that it be authorized to proceed under a tonnage limitation of 35,000 tons in order to assure actual production of 25,000 tons. This was acknowledged on November 20, 1953. The subject is currently under discussion.

CONTRACTS EXECUTED

(*a*) On July 25, 1951, contract No. GS–OOP (D) 12047 was entered into between the United States of America, acting through the Administrator of General Services Administration, and Titanium Metals Corp. of America. This contract took the form of a letter order which provided for the acquisition and installation of facilities at Henderson, Nev., for the annual production of 3,600 short tons of titanium. The arrangement also provided that the facilities should be capable of producing at the rate of 900 tons per year by May 1, 1952, 1,800 tons per year by June 1, 1952, and at 100 percent by September 1, 1952.

At the time difficulty was experienced in fixing specifications for the proposed production. With the assistance of the Munitions Board a specification was agreed to providing for a minimum titanium content of 99.3 percent and maximum allowances for iron and nitrogen. The hardness characteristics were required to be less than 250 Vickers or 61 Rockwell A. This is the equivalent of

225 Brinell. The contract required, however, that ingots produced from the sponge must be capable of processing into commercially useful shapes and finished products.

Although first production was attained in October 1951, the accomplishments under this contract have been disappointing. Through December 31, 1952, a total production of 347 tons was reported against 1,845 tons required. Through September 30, 1953, a total of 1,127 tons has been produced against contract requirements of 4,545.

In the meanwhile the requirements for an improved grade of titanium sponge were increasing rapidly. For instance, a contract entered into on July 24, 1952, with Du Pont specified a hardness of less than 203 Brinell. A contract entered into July 31, 1953, required an average maximum hardness of 170 Brinell. Both of these contracts are described later. This development, while undoubtedly beneficial from an overall standpoint, compounded the difficulties faced by Titanium Metals in bringing this facility into operation as required.

We have recently been presented with a request to increase the advance of $15 million provided for in the original agreement to $16,481,000. This increase is to provide for overruns of cost and the reactivation of four additional chlorinators, as well as for the improvement of the chlorinators now in operation. It is represented by the company that this additional equipment should be reactivated in order to assure operation of the plant at the rate of 3,600 tons per year during the third quarter of 1954. This proposal is now receiving a technical review.

(*b*) A contract was entered into on July 24, 1952, between the United States of America, acting by and through Defense Materials Procurement Agency, and E. I. du Pont de Nemours Co. This contract provided for the expansion of the contractor's existing plant at Edgemoor, Del., which produced titanium tetrachloride and of titanium metal facilities located at Newport, Del., both to the extent necessary to produce 2,700 tons of sponge per year in addition to existing production of 900 tons. The Government agreed to advance the cost of the additional facilities not to exceed $14,700,000. The plant was required to be in operation not later than December 24, 1954.

As stated, industrial demands for titanium metal required improved properties over those stipulated in the previous contract. The specification required a hardness of less than Brinell 203. It was further provided that the specifications might be modified by mutual agreement as further commercial experience was developed.

The experience with this contract has been encouraging. It is not scheduled to be in production for more than 1 year. Construction is now approximately 8 months in advance of schedule and commercial-scale production is expected to begin during the first quarter of 1954. In the meanwhile the contractor is producing titanium metal sponge from its own facilities at the rate of approximately 900 tons per year.

(*c*) A contract was entered into between the United States of America, acting by and through Defense Materials Procurement Agency, and Cramet, Inc., a subsidiary of the Crane Co., on July 31, 1953. The contract provides for the construction of a plant at Chattanooga, Tenn., for the production of titanium sponge at the rate of 6,000 short tons per year. First production is required to begin 18 months following the date of the contract and full production is required within 12 months thereafter, a total of 30 months from contract to full production. The Government is required to advance the cost of the plant, not to exceed $24,950,000.

Here, again, the industry requirement for an increasingly better grade of material is evident. The specification under this contract calls for an average maximum hardness of not more than 170 Brinell for each lot of material. Provision is made for modification of the specification by mutual agreement as further commercial experience is developed. This project is in its earliest stages, a total of $612,308 having been advanced to date.

All of these contracts contain similar provisions for repayment of the advances. The contractor is required to pay an amount for each pound of metal produced which is applied first to the interest and then to the principal of the advance. All provide for return of the facilities to the Government if they become obsolete, thus discharging the unamortized balance of the debt.

(*d*) A contract was also entered into on April 30, 1953, with the Bureau of Mines. This provides for production of a minimum of 180 short tons of titanium by October 31, 1954, from the Boulder City, Nev., station. This operation is now underway.

All of the above contracts employ the magnesium-reduction technique known as the Kroll process. The basic Kroll process is, however, modified in varying degrees by the several users.

(*e*) On January 22, 1953, a contract was entered into with Titanium Metals Corp. of America which provided for the sale to the Government of a maximum quantity of 1,250,000 pounds of titanium metal sponge. The purpose of this contract was to absorb production from the Henderson, Nev., plant which was not purchased by industry and to hold it until it could be absorbed. No deliveries have been made under this contract which will expire December 31, 1953.

POTENTIAL PROJECTS

In accordance with the authorization of August 25, 1952, efforts have been made through a canvass of all potential interests to locate research projects for the production of titanium metal which show sufficient promise of success to warrant substantial-scale pilot-plant operation, if not immediate commercial operations. The objective is to stimulate through Government assistance pilot-plant operation and development work which would accelerate the time when commercial-scale operation of new processes would be feasible.

A number of interviews have been conducted from which seven prospects have been selected as the most promising. These operators have been placed in touch with a confidential panel of the Minerals and Metals Advisory Board of the National Research Council which is investigating and reviewing processes to the end of making suitable recommendation as to action to be taken by the Government. We have asked the Board to advise us as to each process whether:

(*a*) The process holds promise;
(*b*) More research should be performed;
(*c*) Assistance with pilot-plant operation is justified; or
(*d*) Development warrants entry into a contract for operation on a commercial scale.

The review work is not yet complete. We are hopeful, however, from our appraisal of the situation to obtain three projects for other than magnesium reduction which will justify contracts for commercial-scale plants. It has appeared desirable to adopt the policy of seeking a new process not only because of the prospect of cost reduction but improvement of quality as well. Some of these new processes hold considerable promise of achieving both benefits.

There follows a list of the seven companies under consideration to date:

Monsanto Chemical Co.-National Research Corp. (pilot plant)
Electro-Metallurgical Co.: A division of Union Carbon & Carbide Corp. (Discussions to date with this company have resulted in an invitation to submit a proposal for a commercial scale plant)
Horizons Titanium Corp. (pilot plant)
Western Pyromet Corp. (pilot plant to determine convertibility of existing magnesium plant to titanium production. This is the only one of the group using the magnesium-reduction process).
Kaiser Aluminum & Chemical Corp. (pilot plant).
Titanium Metals Corp. of America (pilot plant).
Kennecott Copper Co. (possible commercial plant).

You may be interested to know that we have engaged in discussions with the following concerns which have work on titanium under way:

United International Research, Long Island City
Glidden Chemical Co., Baltimore, Md.
Cooper Metallurgical Associates, Cleveland, Ohio
Jordan Research & Engineering, Huntington Park, Calif.
National Distillers Products Corp., Cincinnati, Ohio
Chicago Development Corp., Riverdale, Md.
New Jersey Zinc Co.

It is fully evident, I think, with the limitation existing on tonnage and funds, that it is incumbent upon this administration to require that any project which it assists be of demonstrated feasibilty and offer assurance that the production contracted for will be forthcoming. If this were not done, the program might be filled and funds encumbered for paper tonnage which would never materialize for industrial use. Such a situation would preclude participation in productive projects which might later be available.

In conclusion I would like to assure the committee that the question of titanium has been of paramount interest and the staff of this administration has spared no effort in attempting to increase production at the earliest possible date. I am sure you are aware, however, that the manufacture of titanium is an extremely difficult undertaking. The techniques even under the magnesium- reduction process are not well established nor widely known. Substantial investment of working capital by plant operators is required in addition to the amount for fixed investment which the Government has advanced in all cases to date.

During the period between August 25, 1952, when the 22,000 ton program was approved and the end of fiscal 1953, the possibility of placing an additional 5,400 tons at the Henderson, Nev., plant of Titanium Metals Corp., was discussed and a contract drafted. This was not tendered to the contractor for execution because of its inability to meet the requirements of the original arrangement. Similar discussions with the Du Pont Co. during the spring of 1953 were not productive because of their apprehensions as to the effects of assuming a dominant position in the industry. Discussions of this latter subject are being reopened.

The committee will also be interested to know that production from the Government-sponsored addition to the Du Pont facilities commenced November 24, 1953. Forecast output of the combined facilities through the first quarter of 1954 is as follows:

	Tons
December 1953	132
January 1954	209
February 1954	251
March 1954	300

Production for the second quarter 1954 and subsequently is forecast as capacity, viz: 900 tons per quarter.

The interest of your committee in the establishment of a substantial titanium industry to support our defense and expand our economy is well known and thoroughly appreciated. You may rest assured that this administration wishes to cooperate in any possible means and the staff is at your disposal if any further assistance or information is desired.

Sincerely,

EDMUND F. MANSURE, *Administrator.*

Senator MALONE. General, will you continue now?

STATEMENT OF BRIG. GEN. KERN D. METZGER, USAF, CHIEF, PRODUCTION AND RESOURCES DIVISION, AIR MATERIEL COMMAND, WRIGHT-PATTERSON AIR FORCE BASE, DAYTON, OHIO—Resumed

General METZGER. Senator Malone, I was touching upon the question of requirements. To proceed a little bit further on that subject, I would for the benefit of those who did not hear previous testimony, and for the benefit of impressing it upon the record, it was testified to by prominent airframe manufacturers on the west coast that the aircraft of the future, and the future was from 1956 to 1960, as I recall it, concerned aircraft with a mark number of 2 to 3½, that those aircraft would require 25 to 40 percent of titanium in weight in the aircraft.

Now, just exactly what does that mean? I am just a little ahead of myself.

Yesterday I heard testimony to the effect that one manufacturer had planned to produce a fighter aircraft with a Mach number in the 2 to 3½, and it was under design——

Senator MALONE. Will you explain the Mach number?

General METZGER. Twice the speed of sound—the employing or requiring 90 percent titanium in the airframe. To revert to the 40-percent figure, because I believe that was pretty generally agreed to, particularly in the fighter type aircraft, agreed to by those manufacturers.

Senator MALONE. Men who know how to make aircraft, so they will fulfill specifications as to speed and maneuverability.

General METZGER. Yes, sir. To go back to that 40-percent figure, and go to the 35,000 tons which is the present objective, which we do not even have in sight as far as material is concerned——

Senator MALONE. And if we did have, it would not be in sight of the amount needed.

General METZGER. That is correct. To confine our thinking for the moment to the 35,000 tons, we know that 35,000 tons of sponge, and that is what the Government is presently supporting and contracting for, sponge titanium, not mill products, 35,000 tons of sponge will produce about 20,000 to 21,000 tons of mill products at present. I believe that was testified to also yesterday by Mr. Bradford, of Rem-Cru.

Senator MALONE. That is on account of the scrap, waste, and grinding material.

General METZGER. That is the yield in mill-product form from sponge.

Senator MALONE. And the scrap at this time is not redeemable and usable in titanium?

General METZGER. Not at present. Part of it may be, and undoubtedly will be some day, but never all of it.

Senator MALONE. They are stockpiling it now largely?

General METZGER. Yes, sir.

Senator MALONE. That is, the companies themselves, not the Government.

General METZGER. Twenty thousand tons. We will use that because it is a round figure, of mill products is 40 million pounds. It is a matter of arithmetic as I figure it here. If we take a fighter aircraft with a finished weight, airframe only, of 13,000 pounds, and take 40 percent of 13,000 pounds—the 40-percent figure which must be in titanium—my figures show 5,200 pounds of titanium in place, finished weight. We know, and it has been testified to by aircraft manufacturers, that there is a manufacturing loss of approximately 50 percent. It requires twice as much mill product to produce a finished weight required. So 10,000 pounds mill product to produce a 13,000-pound airframe with 40 percent in titanium.

To follow the mathematics very roughly here, I figure on that basis we can build in 1 year 4,000 fighter airframes with 38,000 tons of titanium, which is the objective. We are still a long ways from that figure, as I mentioned before. But in order to make those airframes operational, we have to put some engines in them, and some equipment. I personally believe that the engine requirements and equipment requirements for military aircraft will approximate the requirement for the airframe. So using that figure, we will just reduce that to 2,000 fighter aircraft operational. That will not win a war. But that from the testimony which has been given, using those figures, and I hope my mathematics is correct, is the picture as I see it today—2,000 fighter aircraft. No bombers, no support aircraft.

So much for requirements. It is certainly a dismal picture, I am sure you would all agree, dismal to the effect that we have absolutely no assurance on capability at this moment of building the type of airpower which our manufacturers say is available to us, and is essential to us.

Senator MALONE. How many aircraft can you build, General, on 2,000 tons you are getting?

General METZGER. I have not figured that out. It is probably down in the decimal point some place.

Senator MALONE. Do you consider after you have heard all this testimony that we are doing everything we can to produce titanium?

General METZGER. I would like to say that in that respect the Government agencies have cooperated with us. Mr. Ford has worked very closely. He has been very cooperative. We in the Aircraft Production Resources Agency, which is one of my activities, and is a joint-service agency, in that the agency represents both the Bureau of Aeronautics and the Air Force, are in regular consultation with Mr. Ford. I mention him by name because he has testified, and he has a very crucial position in this supply picture. I recognize that in administering Government funds, because I also administer Government funds, that one is under great responsibility to the Government and to the taxpayers. In that administration of funds, and in the contracting for supplies, Mr. Ford has his problems, without question. However, I believe many of those problems can be eliminated and they must be eliminated soon. I am sure most producers of titanium will admit that to bring in a new plant or any substantial additional quantity of material is a 2 to 3 year proposition. Any of the present producers today, if given the go-ahead, with all the Government assistance in the world, all the money they need, will require pretty nearly 2 years to reach the capability of the facility which is put at their disposal with funds.

So time is moving rapidly. The lead time in bringing in additional metal and additional supply is most substantial and must be recognized. Something must be done to relieve those in the Government agencies responsible for administering these funds in support of these expansions.

Senator MALONE. General, I have only been in the engineering business for 30 years. When we got into a problem that we ourselves did not understand, we brought in consultants. Would you think that would be a good policy, to have someone connected with the General Services Administration that understood titanium and understood the manufacture of titanium, and what is necessary in setting up a program?

PRAISES AMERICAN INDUSTRY

General METZGER. I believe that would be very helpful, and I am sure that the General Services Administration would welcome such assistance. However, I am a great believer personally in the honesty and integrity of American industry. When a man comes to me and tells me that he has produced a quantity of material, and let us call it titanium, because that is what we have been discussing, in the laboratory and that he himself is convinced he could produce additional quantities, production quantities of that material in satisfactory quality, that very earnest consideration should be given to his presentation, to a point that if he is willing at his own expense and with his own venture capital to provide the plant at no cost to the Government and that the Government assistance be confined to a guarantee of the purchase of the material produced in his plant at the current

market price, that no further evaluation is necessary. The man should be given a contract and permitted to proceed without all of the boards and review committees and specialists who presently are a part of the system the General Services Administration is required to call upon.

RECOMMENDATIONS

So my first recommendation in relieving this bottleneck, because it really is a bottleneck in my opinion, is that General Services Administration either be authorized or accept the responsibility openly and on record and adopt the policy openly that a manufacturer or a producer of metal who can provide laboratory quantities, as having been produced by the modified Kroll process, or any other process, and who is willing to provide at his own capital expense the plant to produce it, be contracted with on the basis of a Government contract to purchase at the current market price the material produced of a satisfactory quality, and the quality to be spelled out, until the plant is amortized. That is No. 1.

Secondly, we have heard at all hearings that the present modified Kroll process is not a most desirable process. It is a batch process, it is costly. Its lower cost factor or lower limit has not yet been established. We have not yet been able to learn that. I do not believe anyone knows. But in any event, it is costly. It has been testified that every effort should be made to bring into production new processes.

So my recommendation No. 2 is that any company who has a new process and has produced satisfactory quantities of metal in the desired quality, and which companies have the organization, the technical know-how, and some financial stability, be assisted by the Government to the extent of financing pilot production and prove out the new process in pilot production, and that no further review be necessary, or evaluation, on the part of outside consultants.

With those two recommendations, and in each of them in my opinion the Government is amply protected in the expenditure of its funds, if those recommendations can be adopted, I can see daylight. But unless they are, all I can say is that I hope we never within the next 15 years are required to produce any quantity of aircraft for competition with an enemy. That is all I have to say.

Senator MALONE. You heard the testimony yesterday of our very liberal spread of samples with foreign countries. Would you approve sending samples to Austria?

General METZGER. I certainly would not.

Senator MALONE. You heard the testimony that we have sent samples to Austria?

General METZGER. Yes, sir.

Senator MALONE. How far away in point of time do you suppose that sample is from Russia?

General METZGER. It is not too pleasant to think about. I would not feel secure in shipping anything to Austria.

Senator MALONE. Would you not assume that Russia has all the scientific information that Austria has?

General METZGER. Senator Malone, I would not assume it, but I believe from information which is generally in the press that Russia has means of getting too much information out of this country.

Senator MALONE. They probably would not have to go to Austria We have practically every nation in Europe sending materials to Russia and Iron Curtain countries and making contracts with Red China. I understand even our State Department has some kind of committee to negotiate trade with Communist China. So maybe we are going to be even more liberal.

But the chairman of this committee at least understood that we are trying to keep ahead of any potential enemy in preparation for war. I think your recommendations are sound. First, the proving of a process through a pilot plant, which is customary, and many pilot plants have been set up—a pilot plant to manufacture oil from petroleum shale and from coal, where there is probably more than a thousand years of supply, and 250 billion tons of oil from oil shale has been proven feasible.

Now, we have titanium. There has been some very informative material come to light lately about the people located in the Treasury Department and the State Department working together in making this material available to foreign countries, and also in advising our administration continually to save our resources and become dependent on foreign nations, notably Russia and India and other countries. We had a very informative letter which is in our record already. After the Congress of the United States in 1946 had passed a stockpiling act, after ample discussion, and that they should observe domestic buying in accord with the Federal laws, a very interesting letter came to us from the past President, Mr. Truman, which said specifically that was not the policy of the administration. The policy of the administration was to conserve these resources and buy them from other countries, which we were doing, as the record shows.

We purchased zinc, manganese and many other materials at prices higher, the stockpile authorities testified, than they were paying domestic producers, when as a matter of fact always the bait was held out to the American people and taxpayers that they were entitled to get the sweatshop labor products because it would save money. That is not the record. All of that is in the record.

It was very interesting to me to note that Mr. White was one who sent an initial memorandum to that same President advising conserving our own resources for the next two generations and buying them in accordance with this letter that the President wrote to the stockpile authorities.

This has nothing to do with the present authorities, because the most dangerous men in the world are the men who come to believe these things honestly, that they must conserve. They want to conserve this ilmenite by getting the ilmenite from India. They want to conserve it further by getting rutile from Australia, which is very fine idea if it were true. We just happen to have probably more ilmenite than we can ever use in the United States and Canada, and probably in the United States, in concentrated form. We are getting 800,000 or 900,000 tons of manganese a year from India. We have a stockpile, a very meager stockpile—I will not mention the amount—and no one of my acquaintance in the military strategists believes you will be able to get manganese from India when the next world war starts.

So, I am afraid that the evidence up to now is not adding up very good, and that is why the committee appreciates your assistance.

For 2½ years we have been getting 2,000 tons of something that you need 100,000 tons under present conditions, and probably 5 or 6 times that if you get in this war that everybody is predicting. We have been keeping our taxpayers a little upset by it.

President Truman said on July 23, 1946:

> I have today signed the Strategic and Critical Materials Stockpiling Act because it is important to the national interest that the Government have the power to acquire stockpile. It is only because of the overriding importance of this purpose that I am able to overcome my reluctance in signing a bill which reaffirms the application to stockpile purposes of the provisions of title 3 of the act of March 3, 1933, known as the Buy American Act. Those provisions will not only materially increase the cost of the proposed stockpiles, but will tend to defeat the conservation and strategic objectives of the bill, by further depleting our already inadequate underground reserves of strategic materials.

WHITE SAYS IMPORT

In the memorandum to the President of January 10, 1945, initiated by Mr. White, who has become rather famous in his post mortem, he said to the President:

> We could safeguard and conserve our strategic material reserves in postwar years which are now at a minimum level by importing from abroad to meet ordinary annual production requirements.

He goes on to explain that Russia is a great producing country, and we should finance their production.

The committee intends to go a little deeper into this question, General, as to why people become convinced that they have to ship in material at a cost more than the domestic material and gradually cutting down on our own production. I think that would be important to your program, would it not?

General METZGER. Very much so.

Senator MALONE. What do you think about securing ilmenite from India and rutile from Australia in case we had an all-out war using everything at our disposal?

General METZGER. I do not think we should plan on it at all. In fact, I believe it should be the policy of all producers presently in the titanium production, as well as all producers who may come into the titanium business, to produce from ores which are available on this continent. I would even go so far as to recommend that Government assistance be limited in that respect to those who are willing to so produce.

Senator MALONE. At least you would approve of paying as much for domestic materials as you do for foreign materials, would you not, if the Government were purchasing it?

General METZGER. Yes, by all means.

Senator MALONE. Do you think it would be feasible to ship the ores from India, assuming they would be a friendly nation—they are now claiming to be neutral—and did specifically shut down shipments of monazite to the United States by their own order, but let us assume they were friendly and on our side in a fight, do you think you could ship the ore from India in case of an all out war?

General METZGER. No, sir, I do not. A very small fraction of it, I believe, would ever reach our shores. But from a purely business approach or viewpoint, Senator Malone, I believe that domestic

sources should be supported even though I am certainly not preaching isolationism.

Senator MALONE. What is an isolationist? Do you have any definition for an isolationist?

General METZGER. No, sir, I do not.

Senator MALONE. It would not be someone who was a card-carrying American, would it? I am on the verge of organizing such an organization.

General METZGER. To proceed, my recommendation is based upon a realization that time is also required for ore producers to establish the capability to produce ores in sufficient quantity and quality to meet the requirements of our metal producers, and that every encouragement should be given to such ore producers to build the capability of satisfying our requirement in total. The best assistance which we can give is to buy ore from the holders of such ores and the miners in this country or on this continent. That is why I make that recommendation.

Senator MALONE. Do you think that the Western Hemisphere could be defended? The lines of transportation would have at least a better chance of being defended.

General METZGER. I certainly would think so, yes, sir.

Senator MALONE. You are aware, and of course apparently in Washington very few officials are aware, but I am sure you are, if you saved our supply of ores and petroleum and all, when you start to try to find these reserves, then when a war starts, that you are probably preparing for the war after that, and not the war that is under way currently.

General METZGER. Yes, sir.

Senator MALONE. Testimony has shown that it takes 5 to 10 years to develop a real mine, even after you find the ore.

General METZGER. Senator, I do not believe that the surface has been scratched, so to speak, in the exploration or discovery of ilmenite deposits on this continent. There is no incentive particularly. The policy such as I recommend does provide an incentive. It would certainly be most beneficial in developing high grade domestic sources.

Senator MALONE. No one else does either, General, who has any information or knowledge of the mining industry. It is only the people that administer these things apparently that never had any experience or background, and are a little reluctant to call in anyone that has, that believe we must save our material.

General, we appreciate very much your statement. If you will continue to lend your presence to the hearing, we will appreciate it.

Mr. Frederick F. Moskovics, special consultant to the A. O. Smith Co. and I understand he has been called in to many important conferences as far as the production of certain materials is concerned in the Government.

Will you identify yourself for the purpose of the record and make any statement that you care to make at this time?

STATEMENT OF FREDERICK F. MOSKOVICS, SPECIAL CONSULTANT TO COMMANDING GENERAL, AIR MATERIEL COMMAND

Mr. MOSKOVICS. My name is Frederick F. Moskovics. I am an industrial consultant. I am special consultant to the commanding

general, Air Materiel Command and I spend about half of my time with the Air Force and the other half as consultant.

I have been acting as special consultant to General Rawlings for substantially 2 years.

Senator MALONE. Are you employed by the Government or just called in as consultant?

Mr. MOSKOVICS. I am employed by the Government on a per diem basis and I travel wherever I think it is necessary. I particularly was brought in to make a report on the B–52 bomber. After that report I wrote the report myself and it covered the cost and producibility of the B–52 and after that report was completed I was given another assignment of liaison between licensor and licensee on the J–57 engine which is the engine that is used on that bomber as well as others.

Senator MALONE. You ought to be particularly qualified to give us some information as to the desirability of this material under discussion today in the construction of war planes and even commercial planes.

Mr. MOSKOVICS. After I got into the B–52 project I began to see the importance of titanium. I only knew it as an alloying material up to that time. As I got into the engine phase of that project and that is my specialty rather than air frame—I became aware of just what this material meant, with the result that I followed through quite a few processes which could produce titanium. I was particularly impressed with the fact that I do not believe we have taken sufficient timely action on getting material. I can illustrate it with one point. On March 9 and 10 we had a meeting at Wright Field where every producer of material that was known then—I am speaking of sponge as well as the melters—air frame manufacturers and engine manufacturers, it was a high level meeting of practically all manufacturers and producers, at that time all the civilian agencies were represented and we were told that a certain contract for 6,000 tons of sponge was going to be signed in 10 days. You remember that, General? It was going to be signed in 10 days.

That contract was not signed until the middle of July, that same contract, and God knows we needed it at the time.

Senator MALONE. You are talking about 10,000 tons per year?

Mr. MOSKOVICS. I was talking about a contract for 6,000 tons which was later let to the Crane Co. I illustrate that was the time lag. Every civilian agency assured us the contract would be signed immediately. It was a matter of dotting "i's" and crossing "t's" and it was 4 months later before the contract was signed. Ten days was going to have the contract completed but it took over 4 months.

I believe the engine manufacturers now currently are using titanium in what we call the cold section of the engine which is the low-stage compressor, could use every ounce of titanium that could be produced in the next 2 years, I am speaking of the 25,000 tons.

Senator MALONE. 22,000.

Mr. MOSKOVICS. Yes, without an ounce going to an air frame manufacturer, just the 2 or 3 engine manufacturers that are using double compressors.

Senator MALONE. In that event all that would be needed would be the assurance to them that it was available so they could make plans to use it?

Mr. MOSKOVICS. Most decidedly. For instance, the Under Secretary for Air asked me to follow on the use of titanium in engines with certain manufacturers. I went to the Curtiss-Wright Co. at his request and General Powers, who is general manager of the company, and Mr. Hurley is here now—president of the company and could verify this—was very reluctant to put titanium in the J–67 because of the uncertainty of getting material.

It was only after I assured him that the contract for the additional 6,000 tons was going to be signed in 10 days—which was not signed—that they went ahead with the enterprise. Mr. Hannik was present at the meeting and they decided to go ahead and use titanium on the J–67 engine.

The same thing almost took place at Allison. They were reluctant to even consider it. I want to bring up one point that I am sure the figures General Metzger gave are important but here is one that is just as important.

If you save a pound of weight in an engine it may mean, you have testimony, 7 or 8 pounds in an airframe but the question is which comes first, the chicken or the egg?

If the airplane is already designed and you save two or three hundred pounds on the engine you cannot go back and take it out of the airframe.

But, if the airframe designer knew his engine would weigh four or five hundred pounds less now he could take considerable weight out of his airframe.

Stop to think what that means in the case of the B–52 bomber. If they could take 400 pounds out of each of 8 engines that is 3,200 pounds of weight without considering what they could save in the airframe if the airframe was designed with the knowledge that a lighter engine was going to be used.

The thing goes into fantastic figures.

Senator MALONE. Each depends on the other?

Mr. MOSCOVICS. Decidedly.

Take the current design: The engineer takes all the characteristics of the engine but if he knew he was going to have an engine with four or five hundred pounds less weight he would design his airframe accordingly.

I see these rather fantastic figures and I believe there is a calculated risk that has to be taken on source of supply of titanium. I followed just one of them, National Research in Boston. I went there to see them and they told me of their new process. They did not disclose what the process is because it is a patented process, and so forth, they were roughly negotiating with the government agencies at that time.

I have here a sample of their material. They are responsible people.

Senator MALONE. We have a representative of that organization here today, I believe.

Mr. MOSKOVICS. Yes, but I just want to pass that to you. I would say this that in my opinion any responsible organization—that is, financially and technologically responsible—who can make titanium on methods outside of the Kroll process ought to be encouraged in every possible way, financially and technologically responsible I mean.

I believe a calculated risk must be taken. In other words, I would like to have you talk to Mr. Morse. He thinks he can make

titanium without these very critical materials and here is just a letter from one of his customers he gave me this morning, a gentleman who already testified as to the merits of their particular product.

I have no brief for their product but they are representative of what I mean.

Senator MALONE. Do you care to read the letter?

Mr. MOSKOVICS. To Mr. Morse, President, National Research:

> We are quite interested in samples of titanium crystals you recently supplied for evaluation. Both melted very well with no evidence of troublesome volatility. The larger crystals were of excellent quality and purity. The small crystals, although harder, are also of interest to us. Chemical analysis on both these samples showed them to be well within our current specifications.
>
> Accordingly, we are interested in discussing the purchase of tonnage production quantities with you at your convenience.
>
> Kind personal regards.
>
> Sincerely,
>
> REM-CRU TITANIUM, INC.,
> C. I. BRADFORD,
> *Vice President and Director of Operations.*

SHOULD TAKE RISK

Senator MALONE. I do not recall there was a process mentioned but he did emphasize that they needed all the titanium they could get.

Mr. MOSKOVICS. There are other processes. General Metzger pursued one in Cleveland, the electrolytic process. There are a number of concerns. Kennicott Copper is one.

I believe every one of these concerns are responsible organizations, responsible technologically and financially, that can produce the metal outside of the Kroll method and I have nothing against the Kroll methods. They have done everything in the world. They have made titanium what it is today, but they should be encouraged and I believe a calculated risk should be taken.

Mr. Morse, of New England research, is very certain he can get into production without a pilot plant now inside of 18 or 20 months making 15 to 20 tons a day.

Senator MALONE. Let me ask you, Mr. Moskovics: These processes from responsible companies, have they been laid before the proper authorities here in Washington?

Mr. MOSKOVICS. I believe that several of them have been; yes, sir.

Mr. Morse says he is progressing with the GSA and I believe the Horizons' through General Metzger has been presented to the Government and I do not know about Kennicott Copper or Aluminum Co. of America. They are all working on it but I do not know what progress they have made in Washington.

Senator MALONE. There is, I believe, a clause in the contracts for the Kroll process manufacturer to provide for any obsolete equipment due to better methods of manufacture, which there should properly be, and it would be surprising if the GSA, if they are the proper agency, and I suppose that they are, up to this 22,000 tons that the organization, the top organization of the Government has authorized, I suppose they are investigating them.

Do you know, as a matter of fact, what the status is?

Mr. MOSKOVICS, No; I really do not know, but I might add one thing there. In one discussion I had with Mr. Strube, general manager of National Research, he made a rather significant statement to me

and I do not know that Mr. Morse will bear it out, that was that a Kroll plant, which is a chemical method, 80 percent of that plant would be applicable to their method.

Therefore, if you did take a calculated risk on the Kroll front you would not lose it all.

I thought that was rather important.

Senator MALONE. Speaking of risk, if we can believe the newspaper reports that we are in imminent danger of fighting somebody, it seems that the risk of murdering these kids in a slower airplane would cause considerable investigation and calculated risk in another direction to save their lives, would it not?

Mr. MOSKOVICS. No argument as to the value of titanium as a technological weapon in an aircraft. Senator, let's go back a little. You have heard considerable testimony as to quality and methods. Now I am probably the only one in this room who lived through the entire development of aluminum in its commercial applications.

Senator MALONE. It would be very interesting for the record to know that development in detail, because it has been referred to several times that we are now in a stage with titanium that we went through in aluminum and magnesium.

Mr. MOSKOVICS. I take aluminum because 55 years ago aluminum was a tremendous factor in the design of an automobile. Then later developed the cost element, and it still is in Europe, but in America we had to make a lower-priced automobile and the weight was not important so therefore we got away from it from a dollars and cents standpoint and now it is coming back again. But the point is that aluminum 50 years ago was probably nowhere near the metal in a practical way that titanium is today.

Senator MALONE. It was not as near a practical use.

Mr. MOSKOVICS. It was not as near a good metal. We did not know anything about its metallurgy. Heat treatment was unknown. In those days if you got a piece of aluminum that had a strength of fifteen or twenty thousand p. s. i. it was pretty good metal.

Now you can get aluminum up to 70,000 pounds per square inch.

Senator MALONE. Pounds per square inch?

Mr. MOSKOVICS. Yes, that was a development over a long period of time.

I am perfectly satisfied in my own mind going back 55 years, it is a long time to think back, that titanium today is in a far more advanced stage. In other words, I will put it this way. I think I have seen as much development in titanium processing—metals, welding and forming in the last 2 years as I did see in 20 years in aluminum in its early days.

Senator MALONE. You are a scientist?

Mr. MOSKOVICS. No, I am a practical engineer.

Senator MALONE. Well, you are an engineer and you have had experience. Is it your observation and experience that when it is necessary and the profit incentive is there that the scientists and engineers whip almost any problem that might arise, such problems as arose in the practical use of aluminum and such problems as are now arising in the practical use and manufacture of titanium?

Mr. MOSKOVICS. Most decidedly, given a reasonable base to start from, as I think they have in this material, given that, yes, without any qualification.

Senator MALONE. And we have that now.

Mr. MOSKOVICS. Yes, without question.

Senator MALONE. If it were not for preparation for war perhaps it might be a good many years in developing, 15 or 20 years or more, but since we have this incentive and the money is available and can be made available for any new idea that has the appearnce of practicability, then in your judgment if these things are followed up with advantage taken of the present knowledge and the experiments that private outfits have already made in the expenditure of money, with the incentive available here now and present, if it were really followed to the best advantage how long do you think it would be before we would be in what we might call volume production of satisfactory material?

Mr. MOSKOVICS. I should say 3 years, in quantity, you are speaking of?

Senator MALONE. Quantity and quality.

Mr. MOSKOVICS. Let's say 50,000 tons.

Senator MALONE. A year?

50,000 TONS IN 3 YEARS

Mr. MOSKOVICS. I should say with what, with my personal experience I should say within 3 years we should be able to make 50,000 tons of titanium.

Senator MALONE. Usable.

Mr. MOSKOVICS. Usable and good quality material.

Senator MALONE. Do you believe that up to now we have taken advantage of all of the available knowledge and experience and assistance that is available to us?

I am speaking of the Government.

Mr. MOSKOVICS. To obtain raw material?

Senator MALONE. Yes.

Mr. MOSKOVICS. No, sir, I do not.

Senator MALONE. What do you think we should do?

Mr. MOSKOVICS. I should say we should have some group of aggressive industrialists, as well as scientists, who would investigate, and rapidly, every possible method of producing this material that is backed by a responsible organization, financially and technologically, and encourage them in every way by Government financing, by incentives to their own organization, to prove their methods and produce the metal they claim they can produce.

Senator MALONE. Now you were present and heard the testimony that we have now brushed aside 40 or 50 organizations that used to take their turn in passing on all this sort of thing and that now you have the Office of Defense Mobilization that finally passes on the amount after the national defense organization has made their recommendations. Let's brush aside any idea of whether they recommend it enough or not, they are the responsible organization that fixes the amount to be manufactured.

Then you have the General Services Administration that lets the contract. What would you advise after it leaves the Office of Defense Mobilization? Do you think it would improve the GSA if they set up a committee of advisers such as you mention so that they would have the detailed knowledge that is necessary to move on this setup?

Mr. MOSKOVICS. Providing they had the authority and responsibility; yes, sir.

Senator MALONE. They have the authority and responsibility.

Mr. MOSKOVICS. I would say, without any qualification, that it would certainly speed up the processes.

Senator MALONE. Couldn't they just bring in 3 or 4 well-selected personnel to sit down with them and advise then and do it immediately?

Mr. MOSKOVICS. Yes, sir, but I would strongly urge that on that group there be some industrial experts as well as the scientists because the scientists are always reluctant about making a definite statement about going ahead.

Senator MALONE. Would you say a man like Mr. Douglas, of Douglas Aircraft, or Mr. Gross, of Lockheed, or some of these men that have their tongues hanging out trying to get this material would be proper?

Mr. MOSKOVICS. I think there are better types than they, men who have had experience on production of metal.

Senator MALONE. They just use the metal. I mention them because they know what they need.

Mr. MOSKOVICS. They do not know metal production. I would rather take men who have had actual experience in producing metals.

Senator MALONE. Are these men available?

Mr. MOSKOVICS. Yes.

Senator MALONE. Name a few.

Mr. MOSKOVICS. Any top official of the United States Steel Corp., Bethlehem Steel, Republic Steel—almost anybody who has had experience actually producing metal.

Senator MALONE. Men in the manufacturing business?

Mr. MOSKOVICS. Yes, men from Crucible, men that have actually produced metal; there are other benefits that come from this whole titanium picture.

For instance, the steel people are working like thunder to get better steels on better methods.

Senator MALONE. Lighter steel.

Mr. MOSKOVICS. To try to approach the strength-weight ratio. To give a very glaring illustration, this last fall at the Society of Automotive Engineers meeting in Los Angeles Mr. Gross' outfit, in combination with Manasco, presented steels that heat-treated to 280,000 pounds per square inch.

That was a shock. Nobody ever heard of steel of that character. Aluminum people are working just as hard. So by the propagation of this material—of course in neither case have they got the one great advantage that titanium has, which is its noncorrosive qualities, but I can see if we can get sufficient titanium——

Senator MALONE. This is a competitive field.

Mr. MOSKOVICS. You bet your life, and we would make great progress in the other applications.

Senator MALONE. This question comes out of 30 years of background dealing with Government departments as a private engineer. You do not suppose that this competitive question in any wise ever held up the production of this, do you?

Mr. MOSKOVICS. I doubt that very seriously. I will emphasize what General Metzger said. I am a great believer in the honesty and integrity of American industry and I believe you can get experts, you

do not necessarily have to get experts that are now engaged in the steel business, retired men, men over 65.

Being well over 65 myself, I am a great believer in getting men that have been retired to come in that are not now tied in with any of these special interests that could act very honorably and honestly in evaluating these things.

I do not believe there has been any commercial holding up of the thing. I think it is just the lethargy or slow reaction of Government agencies.

I believe there may be some little reluctance to act rapidly on this titanium expansion due to the fact that if they put a lot of money in Kroll process plant it might be obsoleted and they might be criticized in having put millions of dollars in something that was obsolete.

That was one reason I was very much encouraged when one of the officials of the National Research Corporation told me 80 percent of a Kroll plant could be utilized for their processes.

Senator MALONE. Mr. Moskovics, that is where we believe the committee might fit in in some of these strategic and critical materials and fields and titanium is a very fine example—because having the information from men such as General Metzger, we have information from the people who really know what this will do for national defense, then if the Senators really understood the story and they can say a certain number of them would be behind any chance that you take, it might encourage Government officials to take more of a chance.

I realize it is a chance that you are taking with Government money and that is the reason, one of the reasons, that we are giving so much time to this one material. We have 77 materials we are investigating but it just appears that this is one of the materials that we can get all of the material we need, the raw material, at home to manufacture and that once the process, a process which is satisfactory is developed, that there should then be no limit to the amount you can manufacture.

It would just be a question then of need and cost, cost and quality.

Mr. MOSKOVICS. I agree with that except I would like to—you use the word "chance" in these things and I would like to substitute for that "calculated risk."

Senator MALONE. I am a little allergic to that calculated risk.

We have taken so many of them in the last 20 years, but I will go for that if you think it is good.

Mr. MOSKOVICS. I rather think——

Senator MALONE. We took a calculated risk with China. The calculated risk we took was to deliberately lose China.

Mr. MOSKOVICS. That was a different point. I mean the calculated risk in mechanics.

Senator MALONE. We will confine it to mechanics and let it stand.

GREAT PROGRESS MADE

Mr. MOSKOVICS. Let me close with this, Senator. In the last 18 months I have watched production methods of titanium. By that I mean forgability, formabiliy, weldability, heat treatment, and so on.

I would say in the last 18 months I have seen greater progress in titanium in those phases of it than I have in 20 years in aluminum, and I believe today that it could be stated titanium is weldable, it is

formable—I am not speaking of its characteristics of corrosion, strength-weight ratio—I am speaking of just the practical application of practical methods of production.

Senator MALONE. Then, Mr. Moskovics, you have heard the testimony of the General and we have heard other evidence. It is absolutely necessary in the manufacture of war planes—in war it is going to be absolutely necessary, especially if the potential enemy is in possession of it and can make planes out of it, because to be competitive in a war you have to have as good plane and as light a plane, and the maneuverability of the plane and the speed as the other fellow.

Mr. MOSKOVICS. Or more.

Senator MALONE. That is, to give you an even break and that is about all our boys ask for, and that is one thing the Congress of the United States should be able to give them if we are going to send them some place. So then, if it is absolutely necessary and what you say is true, then it is time we put the heat on in the right places around the Government; isn't it?

Mr. MOSKOVICS. Most decidedly.

Senator MALONE. We thank you very kindly for coming before the committee, Mr. Moskovics.

Now, I had intended to call Mr. Morse, but if he will permit me, Mr. Hurley, chairman of the board of Wright Aeronautical Division, Curtiss-Wright Corp., is here, and it is necessary for him to leave very soon.

Mr. Hurley, you have heard the objective of the committee, which is to assure the availability of these critical materials to the United States in wartime, for their expanding economy, and for their security. I know you are a specialist in this business. Your company is very well and favorably known and has a great reputation. Any statement you care to make, any written statement or any comments, you may proceed in your own way.

STATEMENT OF ROY T. HURLEY, CHAIRMAN, CURTISS-WRIGHT CORP.

Mr. HURLEY. Senator, it is my considered opinion that titanium is a must and that we have already approached the position of being too late. We must take any and every step we can to get it.

I talk not from the point of view of something that we are designing but the airplanes the General talks about. If he wants them in 1955 he and I know we must build engines now. We are already making parts for titanium.

We have no reluctance about using it. We think if our boys are going in combat and doing a job, we must have air supremacy. Even with today's prices and with today's difficulties, I would still consider it a must.

I believe we have some problems connected with using titanium. We are familiar with them, but when you turn American ingenuity loose and the production men of America loose on a problem, they come through. The only way you are going to turn them loose is get the metal and give it to them to go to work with.

In my past I have had a lot to do with the making of steel and also with aluminum. I see no problem that we might or should be concerned with or worried about in connection with this effort. I think

we should go right ahead with full confidence. I do not consider it a chance, I do not consider it a calculated risk. I consider it a must and I use the strongest words that I can use.

Senator MALONE. If I understand you, Mr. Hurley, you consider it a must as far as securing material and you do not consider it a chance of being able to use it, you know you can use it if you get it under certain specifications.

Mr. HURLEY. Here are pieces in the room that were made from it. There are all sizes and shapes and kinds. These are just a few.

In some of the newer jet engines that we are talking about we can reduce the weight of bar and forgings as much as 3,000 pounds in an engine.

We have a requirement for the metal in 1955 and 1956.

Senator MALONE. Three thousand pounds?

Mr. HURLEY. Yes, sir.

Senator MALONE. And we are arguing here about letting a contract for more.

Mr. HURLEY. I would not, sir, if it were my responsibility.

Senator MALONE. I am hearing evidence from Government officials responsible for this metal that they do not know whether to let another contract. Apparently several months have passed, 2½ years have passed since the contract was let, producing about one-third of the material that they were supposed to produce under the contract and not much of it up to specifications and the specifications laid down by the Government officials apparently were not very good.

What is the matter with this? Haven't they been in communication with you people who are responsible for delivering the materials that the Air Force needs? Have they ever discussed it with you?

Mr. HURLEY. Senator, our——

Senator MALONE. I am talking about the GSA and Office of Defense Mobilization. Have they ever called you in?

AIR FORCE DILIGENT

Mr. HURLEY. Not to my knowledge, sir. Our contracts are limited to the Air Force and the Air Force has been diligent in placing contracts.

We have worked as a coordinating contractor with American industry to determine the best methods of drilling, tapping, grinding, milling and turning and that contract was placed with our firm by General Metzger's office in Dayton.

I am only qualified to speak on the metal itself when we get it. But I certainly can demonstrate to anyone's satisfaction that we must have it and we must have a lot of it.

Senator MALONE. In other words, your conclusion, having grown up in this business, steel and the materials as they come along, your job has been to use the most up-to-date materials available in manufacturing an efficient engine?

Mr. HURLEY. That is right, sir.

Senator MALONE. And your conclusion is that this metal, if our airplanes are to be competitive in the air with the potential enemy's airplanes, they must have this material?

Mr. HURLEY. Right.

Senator MALONE. And it is your conclusion that it can be made and that it is usable and all you are waiting for is enough of it to use?

Mr. HURLEY. That is right, sir, and we could use more of it right now. I would like to say also that it is required for commercial aviation. The airplane that crossed the country last Friday in 5 hours 50 minutes 12 seconds had titanium parts in it, and that airplane was designed and built to make a profit in a commercial world.

If you can use it there, you can certainly use it anyplace.

Senator MALONE. You agree with the—or were you here yesterday in part of Mr. Douglas' testimony of Douglas Aircraft? They all agreed a pound saved was worth $35 or $40. That would pay for a good deal of material.

Mr. HURLEY. We think the engine ratios are higher than that. The saving you make in the engine or the airplane you collect dividends on through the life of that airplane.

Senator MALONE. What would you say a pound saved in the construction of an engine throughout the life of that plane or engine ought to be worth?

Mr. HURLEY. Senator, I am not prepared to give you a figure that is worth while on that, but I would certainly submit one to you very shortly.

Senator MALONE. We would like very much for you to do that. I want to emphasize again that the work of this committee is to present to the extent an informative report on availability of these critical materials, these 77 materials of which titanium is one, and we do not intend to investigate anybody. If you have made a mistake out there, it is your mistake, and you know more about it than we do, and we know you make your money by not making mistakes, so probably anybody would have made it if you made it.

We are asking the cooperation of men like you who are busy to come in and tell us what you are now telling us. We are demanding the cooperation of the Government officials, and sometimes we get it and sometimes we do not.

But we are not through with the ones where we do not get it.

It is a personal feeling of the chairman of this committee that ignorance has played a great part in this thing and reluctance to call in the people they should call in and start getting the material they need. When I speak of ignorance, I mean the kind of ignorance that is only subject to criticism when they refuse to learn. None of us knows but in holding a responsible position you are not sometimes appointed to that position because you know everything but because you have judgment enough to know where to get the information, and not getting it is the inexcusable sin. Do you agree with that?

Mr. HURLEY. Yes. When you are remote from a problem you are apt to not understand it, not appreciate it, and not do too much about it.

The Air Force and the Department of Defense are very close to it and so are we and therefore I think the Air Force or the other defense departments and industry supplying these things are fully aware of the problem and can do a job.

When you bring in a great many other agencies they are unfamiliar and are apt to be somewhat indecisive and somewhat fearful of moving.

If they are aware of the consequences of not moving I cannot understand why any American would hesitate to move.

Senator MALONE. In my personal opinion, they will not hesitate from here on very long.

Mr. Hurley, do you have any further information for the committee?

Mr. HURLEY. No, sir. I would be glad to submit anything the committee wishes.

Senator MALONE. You said I believe that you save as much as 400 pounds on 1 engine.

Mr. HURLEY. Bigger engines are coming, sir. On the older engines we can save 400 pounds and on the newer engines up to 3,000 pounds on bars and forgings.

Senator MALONE. On one engine?

Mr. HURLEY. Yes, sir.

Senator MALONE. What would be the type of engine and the power?

Mr. HURLEY. The engines——

Senator MALONE. If I ask you for any restricted information, of course you know we do not want it in the record and if it is necessary we will ask you in another way.

Mr. HURLEY. It is classified information and I would have to supply it to you on that basis.

Senator MALONE. We do not want it here. I would like to get at—these larger engines that are coming up you can save 3,000 pounds?

Mr. HURLEY. We would like to have 3,500 tons in 1956 as a minimum ourselves and 5,800 tons in 1957. If we were to be in an emergency at that time we would like to have 36,000 tons ourselves and our licensees should have at least another 36,000 tons.

Senator MALONE. By 1956?

Mr. HURLEY. That identifies no engine and I think I am clear of security in that respect.

General METZGER. That is all right.

Senator MALONE. That is 76,000 tons you would need for your own engine manufacture alone?

Mr. HURLEY. That is the minimum.

Senator MALONE. If we were to be in an emergency.

Mr. HURLEY. That is right.

Senator MALONE. If there is no danger of such emergency the newspapers are wasting a lot of space. We are certainly being made aware of it every day. So, in your judgment you think we should prepare for such an emergency?

Mr. HURLEY. Yes, sir; I do.

Senator MALONE. If we believe such an emergency is in the offing?

Mr. HURLEY. Any prudent man would prepare.

Senator MALONE. You are only one manufacturer. There are other engine manufacturers.

Mr. HURLEY. That is right.

DESIRED REQUIREMENTS

Senator MALONE. What would you say with your knowledge of the industry would be needed if we were to reach such an emergency in 1956 for all of the engine manufacturers?

Mr. HURLEY. There would certainly be 5 engine manufacturers in the business, and I would be conservative in saying multiply it by 5.

Senator MALONE. Three hundred and fifty thousand tons annually for engines.

Mr. HURLEY. Right.

Senator MALONE. Let us assume we do not reach such an emergency but continue along the same lines of preparation that we apparently are headed at the present time but get into the air to whatever extent another war will justify it, what would you say would be your requirements in 1956 and 1958?

Mr. HURLEY. We are making a study now on our present plans. The minimum is 3,500 tons in 1956. That is the very minimum requirement and that is based on the hope that that much will be available. We are making a study now that is not complete as to what we could do if we had the metal available and what other industry should do and I think such a study should be made. Valves and all sorts of things.

Senator MALONE. How long do you think it will be before that study is made available?

Mr. HURLEY. It will be 2 or 3 months.

Senator MALONE. I will ask the question in another way. How much material, how much of this material, titanium, would you use if you knew it would be available in 1956 under the present conditions? Just forget availability the same as you would aluminum. Assume it would be available in the specifications that you need.

Mr. HURLEY. It would be my estimate, sir, if we were to develop our engineering and design against the availability of the metal that we would use approximately—and I would like to check this and advise the committee—about 6 million pounds a month and that would be of the order of 3,000 tons a month if my calculation is right.

If we were to use the amount of titanium in the commercial and military engines that we normally would expect to build, that is what we would use.

That is assuming it is freely available on the market for our use.

Senator MALONE. 36,000 tons per year?

Mr. HURLEY. Yes, sir. I would like to check that and confirm it in writing to you.

Senator MALONE. There are five such organizations.

Mr. HURLEY. In an emergency there would be five. I cannot speak for the other companies, sir.

Senator MALONE. Assuming that the other companies are as aggressive as you are, what would you say generally? Just if the metal were known to be available by 1956 that you think would be necessary for all purposes in engine manufacture.

Mr. HURLEY. I think you could multiply that by three, because I have not given consideration to the propellers, for example, and I am sure the propeller manufacturers would use large quantities of it.

Senator MALONE. That would be 108,000 tons just for engines and auxiliary parts.

Mr. HURLEY. Yes.

Senator MALONE. That would include propellers?

Mr. HURLEY. Yes.

Senator MALONE. But not frames?

Mr. HURLEY. No, sir.

Senator MALONE. I think I heard you say, General, when you talked about frames that there would probably be a like amount needed for engines and that would be 216,000 tons in 1956 without a real emergency, including frames.

General METZGER. If Mr. Hurley's estimates stand up I do not think we would buy engines unless we had airframes to put them in in the quantity he is talking about.

Senator MALONE. Suppose the material were available. All you would need to do is forget availability of the material and design and make frames and engines you need. Then his testimony would stand up.

General METZGER. Yes, sir, it should.

Senator MALONE. You would be talking about 200,000 tons of titanium in 1956. Does that sound reasonable?

General METZGER. The airframe requirement would lag somewhat behind the engine requirements, the lead time on engines and the manufacturing time of the engine itself requires the material some months sooner than would be required for airframe.

I do not want to pin it to 1956.

Senator MALONE. 1957 or 1958.

General METZGER. Yes.

Senator MALONE. A couple of hundred thousand tons you would use if you had it and it would be advantageous——

General METZGER. Based upon Mr. Hurley's estimate of the aircraft program; yes, sir.

Senator MALONE. And with commercial planes just saving money in transportation at the present prices and in efficient war planes.

Mr. HURLEY. Yes, sir. If we do not put it in commercial planes and put it in military planes alone, we are remiss in our job. We have to put it in commercial planes as quickly as we can and to the maximum extent.

Senator MALONE. As a matter of fact, isn't it the record in World War II and in Korea that many of these commercial planes are pressed into use in case of emergency and would be very helpful if they were manufactured so that they could make the speeds necessary?

Mr. HURLEY. That is right. When we can reduce the weight of an engine the airframe manufacturer can take advantage of it, and increase performance or increase range or decrease fuel consumption and he must have that available to him before he lays down basic design of his airframe.

We have to move as fast as we can in the engine business.

Senator MALONE. All you eliminated in Mr. Moskovics' testimony was the matter of his calculated risk. You do not think there is any risk, if you can manufacture the material?

Mr. HURLEY. The only risk you take is if you get a bad contractor and you take that if you build a house or buy an automobile or buy a pair of shoes.

I see no special calculated risk or chance.

Senator MALONE. You are a great comfort to us, Mr. Hurley, I must say.

SUFFICIENT NICKEL AND COBALT

Mr. HURLEY. Thank you. Everyone knows we have enough nickel and cobalt and other things. There is no risk. That is a conservative statement.

Senator MALONE. Would you, Mr. Hurley, take out of your busy lifetime enough to write the committee—there is no hurry, a week or 10 days or 2 weeks—and give us any supplemental information and of course this record is available to you, if you want a copy of it you can get it from the reporter, to round out the information for us. You have heard some of the questions and discussions and you are in touch with the general who has been very helpful to the committee, spending his valuable time in every meeting we have held on this important material. Would you work with him and give us the story as you see it?

Mr. HURLEY. I would be very glad to.

(The following letter was supplied for the record:)

CURTISS-WRIGHT CORP.,
Wood-Ridge, N. J., December 2, 1953.

Hon. GEORGE W. MALONE,
Chairman, Minerals, Materials, and Fuels Economic Subcommittee,
Committee on Interior and Insular Affairs, Washington, D. C.

DEAR SENATOR MALONE: It has always been a deep source of pride to us that the Curtiss-Wright Corp. has pioneered many of the aviation industry's outstanding achievements over most of the 50 years of aviation history. Our Wright Aeronautical Division has consistently led the industry in fulfilling the ever-increasing need of our Air Force for more power with less weight, and this record has continued from almost 20 years ago when we produced the world's first 1,000-horsepower engine and, a little later, the world's first engine weighing just 1 pound per horsepower.

The jet engine has opened a new chapter in aviation with its almost limitless power potential, but we are still in the thick of the fight to realize the maximum from this potential in engines the Air Force can afford to buy.

While the necessity for our country's superiority in the air has required the utmost in engine power it has been no less demanding that this be achieved with the lowest possible weight. Just as the development of new metals and alloys made the jet engines with their tremendous power possible, so are they now the basis for equally revolutionary advances in weight reduction. Titanium, of course, is the key to this second revolution, and the Curtiss-Wright Corp., takes the position that further delay in providing an adequate supply of titanium for the industry is tantamount to equal delay in our ability to produce the aircraft which will insure military and commercial supremacy in the air.

We are attaching a conservative statement presenting some facts as a basis for the above conclusion and a recommendation which might expedite an early increase in titanium production. However, we should also like to emphasize these facts by pointing up some of the tremendous benefits of titanium to airplane performance. Without even considering the weight saving from the use of titanium in the airframe, a 25,000-pound fighter airplane designed around a production type engine made 500 pounds lighter through the use of titanium could be reduced in weight by as much as 5,000 pounds, or up to 20 percent. It takes little imagination to visualize the direct effect of such a weight saving in terms of increased speed, range, load-carrying ability, maneuverability, rate of climb, altitude ceiling, and the like.

In consideration of the facts, we believe that you and your subcommittee will agree with our feeling of urgency with respect to the need for a large increase in the production of titanium and will wish to take appropriate action to accomplish this objective at the earliest possible date.

Respectfully,

ROY T. HURLEY.

Enclosure.

A REPORT ON TITANIUM BY R. T. HURLEY, PRESIDENT, CURTISS-WRIGHT CORP.

CONCLUSIONS

1. Titanium has been fully demonstrated to be essential to superior airplane and engine performance. The ultimate in proof is considered to be the commercial use of titanium in the new DC-7 passenger transport for increasing its payload and safety on nonstop flights from coast to coast.

2. Our minimum estimated requirements for titanium by the end of 1955 appear to be in excess of the supply presently planned to be available at that time.

3. The above estimate includes the requirement for titanium in aircraft engines only. It does not take into consideration the possibly substantial increases in demand resulting either from technical advances in titanium alloys or from their ultimate application to such other Curtiss-Wright products as propellers.

4. Because of the 2- to 3-year period required to design and construct production facilities for titanium, it is possible that it is already too late to take the necessary advantage of the benefits of titanium in aircraft engines planned for production in late 1955.

RECOMMENDATION

1. Establish a high level committee with one member each from the Air Forces, representative air frame and engine contractors and the General Services Administration to provide a positive and accurate picture of the need for a rapid increase in the production of titanium and to recommend a program for its practical accomplishment.

A suggested committee would be—

1. Brig. Gen. Kern D. Metzger, Chief Production and Resources Division, Wright-Patterson Air Force Base, Ohio.

2. Mr. E. F. Mansure, Administrator, General Services Administration.

3. Mr. Donald W. Douglas, president and chairman of the board, Douglas Aircraft Co.

4. Mr. Roy T. Hurley, president and chairman of the board, Curtiss-Wright Corp.

SUPPORTING DATA

1. Weight savings of between 10 and 15 percent may be achieved in an aircraft gas turbine engine by the use of titanium. This may amount to as much as 500 pounds in some engines.

2. One pound saved in an aircraft engine may save 5 to 10 pounds in the design weight of the aircraft it powers. This represents potential cost reduction and increased airplane performance.

3. Based on current planning for engines alone, Curtiss-Wright would need a minimum of 3,500 tons of titanium mill products in 1956 and about 6,000 tons in 1957 against a current total production rate of titanium sponge of about 2,000 tons per year.

4. We estimate that improved titanium alloys now nearing development may allow an increase in the above requirements of up to 60 percent.

Senator MALONE. Thank you, Mr. Hurley. I want to thank you very kindly for your visit here and I know that appreciation will extend thoughout the membership of the committee.

Mr. MOSKOVICS. My words "calculated risk" were not on the use of the material, Senator. I used that entirely in relation to new sources of supply, not in the material. I am enthusiastic about the material, sources of supply.

Mr. HURLEY. I agree.

Senator MALONE. Speaking for 1 Senator out of 96 I hope we get away from all this funny stuff of limiting our manufacture of material and limiting our mining and limiting everything and then rationing everything. One leads to the other and when you start rationing it takes the profit out of it and then you finally can run out of it. It does not make much difference what it is.

Mr. HURLEY. I would like to make one other suggestion.

Senator MALONE. Yes.

Mr. HURLEY. In connection with the committee you form I suggest that committee be staffed by people from the Air Force and aircraft industry and those that make the metal and give the three people who have the immediate concern of doing the job the responsibility of getting together and formulating a program that will work.

Senator MALONE. How long do you think it will take? We fixed responsibility in GSA to secure the amount of material that the Office of Defense Mobilization authorizes. We have had Mr. Flemming before the committee but asked him no questions.

We wanted him to know we were interested in his committee but we intend to have him here again.

He has a great responsibility. It was not clear and is not clear yet until we request Mr. Flemming to appear again, whether he cut the 36,000-ton requirement of the national defense to 22,000 because he did not think the material would be available—he wanted to ration it or something, it may be a holdover idea—or whether he just thought that is all you could use.

But we will determine what the objective is there. But when they fixed the amount, 22,000 it is now, and we have made very little progress in getting the 22,000, the responsibility is then in the General Services Administration to let the contracts and I should say follow through and see what work is done and see that it is done under proper specifications.

However, we have in evidence here the specifications under one of the contracts that does not seem to fit industrial needs. So it is the GSA it seems that would call these men in and how long if you had a telephone call from the GSA, the head of it, Mr. Mansure; as one member of this committee, I know it would take the General as long as it took his plane to go to Washington.

Mr. HURLEY. It would take me half as long. I am half as far.

Senator MALONE. How long do you think if Mr. Mansure put the finger on some of you to fix up a program of this kind, how long do you think it would take you to be here and make such a decision?

Mr. HURLEY. Certainly we could meet within a few days after notice went out and if we had to we could meet in a few hours. I am sure a wise and a considered opinion that would be worth while would come of such a meeting.

Senator MALONE. How long do you think it would require for such an opinion to come out of such a group of men as you and the General?

Mr. HURLEY. We, speaking from our own point of view, would be prepared to have such an opinion come out in a matter of a week or two.

I cannot speak for the rest but I can speak for our use of the material in engines.

Senator MALONE. Mr. Douglas and Mr. Gross seemed to be very perturbed at the lack of it.

I suggest Mr. Gross and Mr. Douglas would probably take the fastest plane they had to come in and tell their story and they already have, as you have yours, so it should take a relatively short time, a week or 10 days to add up what you need and to then get at ways and means of securing it; would it not?

Mr. HURLEY. That is correct, sir.

Senator MALONE. I thank you very kindly. You have been a very great comfort to this committee.

Mr. HURLEY. Thank you, sir.

Senator MALONE. Now, Mr. Morse, I am sorry that we delayed your testimony.

Mr. Morse, you are with the Massachusetts National Research Corp.?

STATEMENT OF RICHARD S. MORSE, NATIONAL RESEARCH CORP.

Mr. MORSE. National Research Corp.

Senator MALONE. What is your address?

Mr. MORSE. Cambridge, Mass.

Senator MALONE. We have asked you to come here because the committee has been informed that you are interested in producing material and might have some information that would be valuable for the consideration of the committee in ways and means of making the proper material to proper specifications available.

Do you have a prepared statement, or do you want to just give us an oral statement?

Mr. MORSE. If I may, I would like to review just what the position of our company has been in this field.

Senator MALONE. We are very glad to have it.

Mr. MORSE. I appreciate the opportunity to present the facts here. We started in 1944 doing research work in the titanium field.

I think, since then we have probably had about as large, certainly one of the larger research groups that I am familiar with.

All of their work has been directed from certain points of view.

First, we have only been interested in continuous processes with the exception of some work on electrolysis——

Senator MALONE. First, what got you interested in this material in the beginning? Do you think there is a commercial future to it?

Mr. MORSE. Certainly.

Every bit of work we have done to now has been with our own funds.

Senator MALONE. You are in this business because you think it has a commercial future?

Mr. MORSE. Yes, sir.

Senator MALONE. And you can profit by it if you can enter into the manufacture at this time?

Mr. MORSE. We initiated our work at a time we thought we could best utilize our technical people who had been working in atomic energy and similar fields of activity. We did not foresee, as many other people, this build-up of war strength after the war so at the moment almost all our work is for immediate war use, all our original decisions were based on peacetime economy immediately after World War II. We have laid down certain lines of the work first that we would not concern ourselves with the Kroll process, not that we do not have great respect for it; it has been a great service to the country, and the Bureau of Mines should be commended for what they have done, but we saw no particular advantage in competing with a known process from a commercial point of view. Except for the work on electrolysis we have only been interested in processes that were potentially continuous and therefore substantially less capital investment was necessary.

We were also interested in materials that were readily available in North America. Those were the basic restrictions.

Senator MALONE. You are talking about the raw materials available in North America.

Mr. MORSE. Yes, sir.

Senator MALONE. Why would you limit your work to the raw materials available in North America?

Mr. MORSE. It seemed to be good business judgment either in war or in peace.

Senator MALONE. Why do you think that they might be limited in time of peace?

Mr. MORSE. Well——

Senator MALONE. Shipment from foreign countries?

Mr. MORSE. I do not think it is entirely a matter of shipment but it is a matter of ability to deal with the Indians and other people around the world. We would rather deal with Americans.

Senator MALONE. In other words, you take the position that as long as these foreign countries are sometimes indecisive as to which side they are on or whether they will be neutral or whether they will barter their materials and that the government in each case is almost always in full control, you think that even in peacetimes you are taking a chance of being blackmailed a little to get the materials?

Mr. MORSE. Yes, sir, that has been the experience of friends of ours in the business world.

I do not say that it is the dominating factor. There are 400 million tons of ore that are known to be available in Canada and that is the raw material we have been primarily concerned with.

Senator MALONE. Say that again.

The raw material where?

Mr. MORSE. In Canada.

Senator MALONE. I think that will be available.

Mr. MORSE. We have been assured it is available right now. This is slag.

Senator MALONE. Your testimony in that regard fits in with the work of the committee and that is another phase of it, the availability of this material in wartime. Of course, for an expanding economy and for our security—but I was very much interested that you have taken cognizance of the dangers.

POOLED EFFORT

Mr. MORSE. I want to make it clear that 3 years ago we became associated with Monsanto Chemical Co. so really in giving testimony here I am speaking for National Research Corp. and Monsanto Chemical Co.

Under an agreement we have everything Monsanto has in the titanium field and everything we have has been pooled. It became apparent 3 years ago the rate of our expenditures was such that we could not support them; we felt that ideally a partnership with a chemical company would get this program going faster as compared with any other partnership we could conceive of.

Senator MALONE. Right at that point—Monsanto Chemical Co.—what is the latitude of their work? Do they cover a wide field in chemicals?

Mr. MORSE. Yes, they are the fifth largest chemical company in the United States I believe.

Senator MALONE. I noticed a newspaper dispatch a few days ago, The Monsanto Chemical Co. had withdrawn from the National Manufacturers Association.

Mr. MORSE. I read that.

Senator MALONE. Giving as a reason that the National Manufacturers Association, if I remember the dispatch, were against the protection afforded the workmen and investors in this country through some kind of duty and coming out for free trade, free competition with sweatshop labor countries of Europe and Asia along with our own labor.

Did you understand it that way?

Mr. MORSE. I only know what I read in the newspaper and I do not usually believe that; so I do not know the facts.

Senator MALONE. My experience is the boys do a good job in reporting. Sometimes they emphasize what they consider important and sometimes some of us think that they missed what we thought was important, but then we can be wrong, too.

Mr. MORSE. I just want to make the point that I am not speaking for the National Research Corp., but speaking for the joint venture.

Senator MALONE. It is clear.

Mr. MORSE. One of the main reasons we are particularly happy with our relationship with Monsanto is it has enabled us to rapidly expand our project and make use of their management and engineering experience. We feel preparation of raw materials is a very important part of our project. Sometimes people overlook that. There we have drawn heavily on Monsanto.

We are currently operating a pilot plant at Dayton and Everett, Mass., and Cambridge and doing work at St. Louis.

It is one of the big programs for us as well as Monsanto and has been for some time. I must say the longer we are concerned with the problem of making cheap titanium the more impressed we are with the problem. It is not an easy one.

I think there are very capable companies in this country working in this field, and have been for some time, and we have respect for them. It is a tough nut.

Senator MALONE. From the progress you have made and the understanding you have of it at this time, is it your opinion that there will be new processes come up with lower cost of manufacture and perhaps greater latitude in the quality of the material?

Mr. MORSE. Yes, sir; no question about that.

Senator MALONE. Go ahead.

Mr. MORSE. We produced sufficient metal by several processes, at least five, to demonstrate there are other methods. The engineering problems of translating it to commercial production are great and the risks are high. In many cases the risks are so high that we hesitate to take them based on a military economy at the present time, which is what we have.

Senator MALONE. You think we are now in a military economy?

Mr. MORSE. Yes, sir, so far as titanium goes. It is on allocation.

Senator MALONE. Go ahead.

Mr. MORSE. I think we have now reached the point where we have to decide whether we are going to curtail our expenditures, the pilot plant and engineering expendtiures, or whether we are going to find some means of getting Government assistance.

It is about that simple. The kind of technical problems with which one is faced in titanium are in many ways comparable to the ones we had in atomic-energy days and still have.

EXPERIMENTATION EXPENSIVE

You cannot do the experiment on a small scale. It would be nice if you could but very often we are concerned with materials of construction, extreme temperatures, highly reactive metal which most people have never tried to handle at temperatures with which we are concerned and you cannot get the kind of engineering data one would like for a plant except on a big test pilot plant.

That is expensive work. We have now spent very nearly $4 million in this general field without any Government support.

Senator MALONE. What stage do you think you have reached in your experiments?

Mr. MORSE. We have two processes, either one of which, in the opinion of engineers of our company and Monsanto, potentially could produce titanium with perhaps a third to a half less capital investment than the present Kroll-type plant as we know the Kroll process.

Senator MALONE. You speak of capital investment. What about the cost of the material?

Mr. MORSE. A similar reduction in cost also.

Senator MALONE. You say about one-half of the cost?

Mr. MORSE. I would not like to say. We are getting into accounting and what is cost and it is difficult. Based on our analysis of a Kroll plant it would be substantially less.

Senator MALONE. Substantially less than in the cost of the production of the metal?

Mr. MORSE. Yes.

Senator MALONE. Do you produce sponge and metal from the sponge rolled into sheets?

Mr. MORSE. No, sir. We have never operated any process which produces sponge as it is known. When you say sponge, I assume you mean Kroll-type material.

Senator MALONE. That is the only kind that is now commercially being used.

Mr. MORSE. One unit would go directly to an ingot. That process is a ton-per-day pilot plant which we consider a large pilot plant. Parts of that unit have operated, the reaction we know is sound. We think the engineering associated with the design and construction of a large plant is such that we could not in good faith guarantee to get into operation in 1956 with the process but we are still continuing expenditure of funds on it.

Senator MALONE. You think it would require 2½ or 3 years to get into production?

Mr. MORSE. I do not know. If we knew——

Senator MALONE. What is this? A batch process?

Mr. MORSE. No, sir; it is a continuous process. That is the only process we are interested in.

That particular unit was looked at by the GSA people about 2 years ago, and they were extremely cooperative. They had a technical team examine it and they offered to give us financial support—at least so said orally, we never got to the point of negotiation—in order to speed up our activities.

Senator MALONE. Were you then satisfied that you could produce the material? You were then experimenting with it.

Mr. MORSE. It comes to the definition of experimenting.

We had made metal and knew the reaction worked. We felt perhaps with Government assistance we could go faster than we would be willing to do with our own funds. We have approval of the process, that is technical approval. A feasibility report was prepared, and then it was our decision not to take Government funds.

The reason was we felt that conceivably work we were doing on a small pilot-plant scale might prove successful sooner and we would then be in the embarrassing position of having taken Government funds for process A while process B turned out to be the best one.

Senator MALONE. What is your position now?

Mr. MORSE. Exactly that thing has happened.

Senator MALONE. The second process has proven to be the best.

Mr. MORSE. Well, it may or may not be in the long run but at least it is more adaptable in our opinion to large-scale plant construction sooner.

Senator MALONE. And it is a continuous process?

Mr. MORSE. Yes, sir.

Senator MALONE. What would you call the process? Is it a chemical process, electrolytic process?

Mr. MORSE. It is a chemical process. We have worked electrolytically and have been producing metal electrolytically for several years but we have not been able to develop any electrolytic process which seemed to lend itself in our judgment, to a continuous operation and would have the engineering chance of success that we think our current proposal to GSA has.

Senator MALONE. It is also a chemical process, your second?

Mr. MORSE. Everything is chemical basically I think. It is a continuous reaction.

Senator MALONE. Continuous reaction?

Mr. MORSE. Yes; we go from the ore through chemical steps to produce crystals. It is not a sponge. You have to see it to know what it is. It is a combination of different-sized crystals and that is the form in which the material comes directly from the process without crushing or grinding.

Senator MALONE. This material is melted and rolled into sheets?

Mr. MORSE. Yes, sir.

Senator MALONE. Similar to the way the sponge is handled?

Mr. MORSE. Yes, sir.

We have reason to believe it will melt somewhat easier. We have been melting ourselves. We have supplied samples to Rem-Cru, Republic Steel, Mallory Sharon. I do not mean to say we do not have difficulty with this process. It is a tough one.

Senator MALONE. That is your second one?

Mr. MORSE. Yes; but it is the one right now which has the best chance of doing the work, going to production in 1956.

Senator MALONE. You think with this process you can get into production by 1956?

Mr. MORSE. Late 1956.

Senator MALONE. What do you consider a large plant?

Mr. MORSE. Twenty tons a day would be the minimum size we would want to construct. That is limited not by the reaction but by the cost of our raw materials. That has been a significant part of our research on how to make starting materials. That is a continuous process and has been running about 6 months on a pilot plant.

Senator MALONE. Preparation of your raw material?

Mr. MORSE. From the ore.

Senator MALONE. You are using the ilmenite ore?

Mr. MORSE. Slag. It is a byproduct from the pig-iron operation in Canada.

Senator MALONE. They turn out pig iron and the slag contains ilmenite?

Mr. MORSE. Yes. We presented a proposal to GSA on August 12.

Senator MALONE. This year?

Mr. MORSE. Yes, sir. We made it very clear that additional pilot-plant work was required. It was our understanding that the Government wished to proceed as rapidly as possible in the sense that you might very well be taking risks which you would not take in peacetime. We included in our proposal the idea that we would simultaneously design and build a larger-scale pilot unit concurrently while completing our plant site surveys, site clearance, and all the things which take 6 or 8 months in a 2-year plant program.

Senator MALONE. You have discussed with the General Services Administration then the construction of a 20-ton-per-day plant?

Mr. MORSE. Yes, sir; 6,000 tons a year.

Senator MALONE. Wouldn't that be more than 6,000 tons a year?

Mr. MORSE. We like to figure a 300-day year.

I think that is a conservative engineering estimate on a new process.

Senator MALONE. Being a continuous process and if it were successful you would not stop on Sunday, would you?

Mr. MORSE. No, sir.

Senator MALONE. You are merely taking time out in that estimate for any improvements or breakdowns or failures?

Mr. MORSE. Yes, sir.

Senator MALONE. What is the status of your operation with the GSA?

FRARY COMMITTEE

Mr. MORSE. The people we have talked to in GSA have been very helpful and very appreciative and I think so far as I am concerned they try to do as much as they can to get this thing started. I should point out that there has been some discussion of a committee to review processes.

I am wondering if you are aware of the Frary committee which has done that? We were asked to spend a day with that group.

Senator MALONE. Who is Frary?

Mr. MORSE. He is chairman of the Minerals and Metals Advisory Board.

Senator MALONE. Is that General Services Administration?

Mr. MORSE. That is another Government agency. I cannot tell you who runs it.

Senator MALONE. I see.

Mr. MORSE. It is under the National Academy of Sciences, I believe.

Senator MALONE. That is a very well-known and very efficient organization.

Mr. MORSE. Yes, sir, they established a committee, as I understand it, of which Dr. Frary was head and had very competent people on it. We spent a day with them, as I suspect other people did telling them in considerable detail all the processes with which we have been concerned.

After our filing of a certificate of necessity, request for certificate, and a proposal to the National Production Administration which we did on August 12, General Services Administration, through the Minerals and Metals Advisory Board, sent a subtechnical committee to visit us at Cambridge and Dayton and Everett.

Senator MALONE. Is that a subcommittee of the committee from the National Academy of Sciences?

Mr. MORSE. No, sir; as I understand it this was specifically appointed by General Services Administration.

Senator MALONE. But with outside scientists appointed?

Mr. MORSE. These were three people we mutually agreed upon as being acceptable to learn the details of our process.

Senator MALONE. What were their names?

Mr. MORSE. James Long of the Bureau of Mines who has been familiar with the Kroll process for many years, a very competent engineer, Dr. Old of A. D. Little Co. at Cambridge, a metallurgist, and Dr. Reed of General Electric Co.

Senator MALONE. Did they make a decision?

Mr. MORSE. As yet I do not know. I understand from oral conversation with GSA this morning which is the first word I have had since the committee saw us that they do not feel we are quite ready to go ahead with a full-scale plant and that is correct.

Our proposal said that. We are trying to buy time and the only way we can buy time is to telescope engineering studies and plant design in the same proposal.

Senator MALONE. You feel your own conclusions are then that as you constructed your pilot plant and operated it at the same time you are building your large plant that you would acquire the additional information necessary before it was necessary in the construction of your large plant?

Mr. MORSE. That is right.

Senator MALONE. You would complete your pilot plant studies ahead of the necessity for that information in the construction of your large plant?

Mr. MORSE. Actually we are doing that now. It is over 3 months since our discussions about this and we have gone ahead with our own funds on the assumption, rightly or wrongly, that we were going to have some arrangement with General Services Administration to proceed.

Senator MALONE. You feel that now you have completed the necessary pilot plant work?

Mr. MORSE. No, sir.

Senator MALONE. How long will it take?

Mr. MORSE. SIX months. I think the lawyers would take about 6 months so we would come out about the same time.

Senator MALONE. That is they would take 6 months in figuring out a contract for you before you secured any Government money, is that it, that 6 months' period?

Mr. MORSE. Well, we are trying to overlap this problem——

Senator MALONE. I do not understand yet about the overlap. In other words, if you are doing it simultaneously you would be constructing your main plant before you had your information?

Mr. MORSE. You would be doing design. You would not actually be doing construction. We would be doing design work on the main plant while completing engineering data in the pilot plant.

Senator MALONE. Anything that was not quite complete you would wait?

Mr. MORSE. Yes, that is the way we did things in the war.

Senator MALONE. You feel that a good part of your plant would be designed before you needed the information to complete the design and you would be getting this information in your pilot plant?

Mr. MORSE. Yes, sir. That is particularly true of the raw materials preparation.

Senator MALONE. There is a problem but what you feel you will whip in time for a continuous design and start your construction of the raw material part of the plant in 6 to 8 months. How long would it take to construct it and get it into operation?

Mr. MORSE. Late '56 would be the best we could do.

Senator MALONE. It would be then late '54 before starting it and it would take a little more than 2 years?

Mr. MORSE. Yes, it would be running.

Senator MALONE. 20 tons per day?

Mr. MORSE. This is not an easy problem.

Senator MALONE. Do you think there is anything in the problem that you will not solve?

Mr. MORSE. No, sir.

Senator MALONE. You feel it is entirely safe to go ahead?

Mr. MORSE. To go ahead stepwise. We would not make technical decisions until we get further data as a result of pilot plant work but I am certain that will come out. We are running on a 24-hour basis producing metal.

Senator MALONE. But you do not feel you are taking a chance spending Government money that you will solve these problems in plenty of time to complete the plant?

Were you asking for an advance in money or a contract to buy your material?

Mr. MORSE. Our proposal was very similar to the arrangement the Government has with National Lead, Du Pont, and Crane. We understand that the Government does not favor the idea of purchasing product over a long period of time. We have not discussed that in detail but I think I can say we are perfectly willing to take our chances on meeting the market price of metal.

Senator MALONE. Whatever the market is, at the time?

Mr. MORSE. Yes, sir.

Senator MALONE. Would you be willing, just for information, it is not a committee prerogative, but make a contract with the GSA on

the basis of whatever the market price is for the metal if it was not readily salable in the open market, they would take it at the market price, whatever it was at that time?

Mr. MORSE. I think about all we want is as good a deal as Du Pont has, for example. We think it would be unfair for us to compete now with two producers who already have a very favorable arrangement with GSA with respect to loan and obsolescence of facilities. We would have the same problem with a new process.

Senator MALONE. The evidence does not show you have very much competition.

Mr. MORSE. They are pretty smart people.

Senator MALONE. It is also a large market?

Mr. MORSE. Yes, sir.

Senator MALONE. That is your negotiation with the General Services Administration in any case as to how this matter is arranged. Are there any producers in in any field on this committee from the National Academy of Sciences or are they just pure scientists?

Mr. MORSE. That is a relatively small committee. Dr. Frary is a retired research man.

Senator MALONE. Give us the name.

Mr. MORSE. Dr. Frary, Professor Hunter of Rensselaer Polytechnic Institute who probably is——

Senator MALONE. Who is he with?

Mr. MORSE. Rensselaer Polytechnic Institute. He is retired and has had considerable experience in the field.

Mr. MOSKOVICS. The father of titanium.

Mr. MORSE. Curtis, I do not know his first name, Director of Tennessee Valley Authority; long of the Bureau of Mines.

Senator MALONE. Director of what?

Mr. MORSE. TVA, Tennessee Valley Authority.

Senator MALONE. Where was he formerly?

Mr. MORSE. I do not know. That is the only connection I know about him.

Senator MALONE. Just four members?

Mr. MORSE. Yes, sir.

Senator MALONE. Do you have any further information you would like to give the committee in regard to this process and its imminence?

GOVERNMENT ACTION A FACTOR

Mr. MORSE. I think its imminence depends entirely on the extent to which the Government wants to speed it up. I think we have done more than we could be expected to do to date.

Senator MALONE. It is not the prerogative or objective of this committee to try to influence you. We are glad to have you here to offer any information and if you have anything additional we would be glad to have it.

Mr. MORSE. I should point out, this may be repetitive, that the problem of producing titanium is not an easy one. In many ways it is comparable with some of the atomic-energy problems we had in the war. I think there is a great deal more industrial effort being directed toward process development than perhaps some people are aware of. I do not think it is complete reluctance on the part of industry to go

ahead. It is a fact that they are not ready to go ahead from an engineering and technical point of view. I am sure Du Pont for example, with the tremendous organization they have, could expand the Kroll process relatively soon and produce more metal.

Whether they want to, I do not know.

Senator MALONE. There seems to be a widespread opinion that there will be a process come up from some source, electrolytic, chemical, or some other process, continuous or not, that will be producing titanium at a lower cost.

Mr. MORSE. Yes.

Senator MALONE. That the committee does not know anything about and does not intend to go into the technical phases of the subject. But we are interested in knowing who is interested in producing it and anything about the process they care to tell us about what they think and its status. The status of yours is that you are going ahead with the pilot plant you hope to get Government money and a contract on the same basis the three contracts have already been let and that is about the status.

You have no positive information, you are either going to get a contract or be refused.

Mr. MORSE. We will discuss it tomorrow with GSA. Unless we have GSA assistance at the large pilot-plant level we are going to slow up our activity. It seems to me that the function of Government, if there is one supporting industry here, should be beyond the research stage at least, and certainly there are adequate private funds for that.

Senator MALONE. The function of Government right now is to get out of industry except where it is necessary, in the national-defense category, I think.

That is at least our hope.

This is a national-defense material.

Mr. MORSE. That is right, and that will be the only use for some time to come.

Senator MALONE. That is not the evidence.

Mr. MORSE. Based on present production. It will all be consumed.

Senator MALONE. Based on present production you are not going to use it anyplace.

Mr. MORSE. Well, that is about right.

Senator MALONE. Except make paperweights. I hope to get one of those.

Mr. MORSE. Would you like this one? That, as far as we know, is one of the first shaped castings with the technique we have developed for actually casting titanium and getting a pretty good surface. The problems of holding titanium are difficult.

Senator MALONE. I think you will be a better witness after you have your talk with the GSA.

Mr. MORSE. Do you want me back tomorrow afternoon?

Senator MALONE. We will call you. Thank you very much. We will recess until 2 p. m.

(At 12:45 p. m. the subcommittee recessed until 2 p. m.)

AFTER RECESS

Senator MALONE. The committee will be in order.

We want to make every effort to finish today. If we do not finish

and complete the testimony, the chairman considers this so important a subject, and the information that is coming to light, that we will continue in the morning because we are in hopes that further hearings on titanium will not be necessary. In other words, we can invite briefs and further information to be filed with the committee if any company or any individual has anything further to offer.

We will start the hearings this afternoon with Mr. E. T. Goodridge, president, Horizons, Inc., and Dr. Eugene Wainer, director of research, Horizons, Inc., accompanies Mr. Goodridge.

Mr. Goodridge, you were here this morning?

STATEMENT OF E. T. GOODRIDGE, PRESIDENT, HORIZONS, INC., ACCOMPANIED BY DR. EUGENE WAINER, DIRECTOR OF RESEARCH, HORIZONS, INC.

Mr. GOODRIDGE. Yes, sir.

Senator MALONE. You know the objectives of the committee. I want to say again that there is no disposition on the part of the committee to be anything but helpful. We know we are in a new field, as we are in the production of uranium ores. When we held 2-day hearings in Salt Lake City it was very plain there if we treated our American producers one-tenth as well taxwise as we do the foreigners, we probably would have uranium ore running out of our ears in 2 or 3 years.

It is also becoming plain to the chairman of this committee that if we listen to the potential and actual users of titanium, and to the men who know how to go about the establishing of pilot plants and developing new processes in the production of titanium, that we could probably bring about the same thing in titanium in about 4 or 5 years.

We have had 3 years of experience, and very little has been produced. At the moment we are getting the raw materials from Australia and India, I suppose saving ours like we do every other mineral. That seems to have been the policy for 20 years, as I read this morning from a memo from Mr. White to Mr. Truman, advising saving our materials for a couple of generations, and buying them from other nations.

Mr. Truman wrote a letter—I will not say it was based on the memo of White—that the policy of the United States was to buy foreign materials and save ours. There is also a little danger in that procedure, that is, as the General has so well said, and others, that we could wake up even in peacetime, and, for example, India could stop the shipments of manganese from her shores, just as she did one time, without waiting for a war.

In wartime, regardless of whether India further develops her neutral position or whether she joins us or joins our potential enemy, according to the testimony of the men I know who plan our strategy, it would be impossible to get ships across either ocean in sufficient number to get the material. So we could be whipped with submarines and atomic bomb warfare by destroying the ports without very much trouble by anybody.

Mr. Goodridge, the committee is interested in assisting in getting titanium. We are not interested at the moment in covering any other

subjects. Under Resolution 143 we are not finishing until we have some expert testimony on the transportation lines that can be kept open in wartime. So if you can help us, we will deeply appreciate it.

You may submit any statement, written or oral. Will you identify yourself for the purpose of the committee and proceed in your own way.

ELECTROLYTICS PRODUCTION

Mr. GOODRIDGE. My name is Edwin T. Goodridge, president of Horizons, Inc., from Princeton, N. J., and Cleveland, Ohio.

Horizons, Inc., was formed in 1946 by Dr. Eugene Wainer, the former associate director of research of the titanium alloy division of National Lead. He had been in the field of titanium since 1934. Horizons was started to engage in research, physics, metallurgy, ceramics, and chemistry.

In 1949 Horizons was entrusted with a small research contract from the Office of Naval Research, to develop electrolytic means for the production of titanium metal. In the early part of 1950 the initial results were sufficiently encouraging to permit the expansion of that program considerably and we have been diligently working in the field of electrolytics production of titanium since then.

Senator MALONE. Since 1949?

Mr. GOODRIDGE. Since 1949.

Senator MALONE. And you have been interested in titanium as a metal since 1934.

Mr. GOODRIDGE. That is correct, sir. There have been electrolytic processes developed by Horizons not only in the field of titanium, but eight other metals as well. I bring those in to inform you that this is a general process for production of metals by electrolytic methods.

There have been two processes developed, and we think that the first process, which I will refer to as No. 1, is now ready for pilot plant production. We have had competent engineers making objective studies.

Senator MALONE. They are both electrolytic processes?

Mr. GOODRIDGE. They are both electrolytic. To make studies of our No. 1 process, we have submitted to the Department of Defense and General Metzger in particular the plan to go ahead with the pilot working out of the No. 1 process.

The No. 2 process, although encouraging, at this particular time requires a considerable amount of additional research, and we are proceeding diligently with that research at the present time, concurrently with our hopes and presentation of the first process.

Dr. Wainer, who has been directing this research, is more competent than I to answer any technical questions that you may wish to ask.

Senator MALONE. I think you have probably given us the important information for the committee. You are now discussing, I understood you to say, with General Metzger and others, the possibility of a Government contract?

Mr. GOODRIDGE. Government piloting of the first process, to prove the cost that our engineers have made.

Senator MALONE. You would have the Government take over and build the pilot plant and operate it?

Mr. GOODRIDGE. No, sir; we would operate it.

Senator MALONE. The Government would furnish the money to construct the pilot plant?

Mr. GOODRIDGE. We would hope so; yes, sir.

Senator MALONE. And would they furnish the money to operate it, or would you operate it?

Mr. GOODRIDGE. The first phase would not require very long operation. I think we estimate from 2 to 4 months after the pilot plant is constructed. After that we would supply, which we refer to as phase 2, going to a ton a day, I believe, sir.

Senator MALONE. You would hope to construct a 1-ton pilot plant?

Mr. GOODRIDGE. In phase 2. We have to prove our costs. We feel our electrolytic know-how, sir, is among the best in the world. I say that very humbly. I feel it is. It is my opinion, of course. However, we have to prove to other people who are competent in this field that what we think we have accomplished has been done.

Senator MALONE. Then after you prove the feasibility of the process through a pilot plant, what would be your next step?

Mr. GOODRIDGE. It would be to go to the 1 ton per day plant.

Senator MALONE. Your pilot plant would be less than 1 ton per day?

Mr. GOODRIDGE. Yes, sir.

Senator MALONE. How big would it be?

Mr. GOODRIDGE. In pounds of production?

Senator MALONE. Yes.

Mr. GOODRIDGE. That is 50 pounds per day, I think.

Senator MALONE. How long would it take, in your judgment, to either prove or disprove the process so that you would either want to go to the 1-ton pilot plant or quit?

Mr. GOODRIDGE. Nine months.

Senator MALONE. Then how long would it take you to prove it, in your opinion, through the 1-ton pilot plant to the point where you either discard it or go to regular production plant?

Mr. GOODRIDGE. May I answer that question by a statement, sir? I think we might be able to possibly skip the 1-ton per day pilot unit if the results were sufficiently scientifically satisfactory.

Senator MALONE. Then what would you be asking the Government to furnish? Money to build the plant itself?

Mr. GOODRIDGE. Possibly.

Senator MALONE. I do not think I have any questions. You are just in the process of trying to develop your ideas.

Mr. GOODRIDGE. I think they have been developed, sir, but I think we have to prove them.

Senator MALONE. Proving the practicability.

Mr. GOODRIDGE. Yes, sir.

Senator MALONE. If Dr. Wainer has any further information that he thinks would be helpful to the committee, the committee would like to have it.

Dr. WAINER. Yes; I would like to make an addition, if I may. These processes are designated ostensibly as electrolytic processes. They have some peculiarities about them that I think might be of interest.

The power requirements on this particular type of approach is approximately half that for the Kroll process, as we know it. Secondly, at least in the laboratory, we are able to make metal, this remains to

be proven in a larger scale, of a quality which is at least equal to the best of the average as available in the Kroll process.

Senator MALONE. What would be that quality?

Dr. WAINER. At the present time in the laboratory the quality is 140 to 150 Brinell.

Senator MALONE. And that is a workable product?

Dr. WAINER. Yes, sir; that is quite true.

Senator MALONE. You did not want to say anything about the process further than that?

Dr. WAINER. No, sir.

Senator MALONE. You are ready for a small pilot plant.

Dr. WAINER. Yes, sir.

Senator MALONE. We are just interested in your procedure. We are not here to either direct or request anything from the GSA. That is their business. But we will keep in touch with GSA and see what they intend to do. So far very little action recently it seems has taken place. I do hope they equip themselves, if they are the final administrator of this program, after the special committee of the Office of Defense Mobilization has determined what the amount of such material is necessary. I have understood now from their testimony that they are responsible.

We also intend to take it up with the Office of Defense Mobilization, Mr. Flemming. He has been before the committee, but is not equipped, of course, to testify, because he has just taken office.

Mr. Mansure just assumed his responsibilities a few months ago. He is not responsible for anything that has gone on before. But both of them will be responsible from now on, and we intend to keep in touch with them.

Dr. WAINER. I do not know whether Mr. Goodridge made this point, but we have a recommendation from General Metzger's office, a favorable one, to GSA to proceed with this pilot plant stage operation we are talking about.

Senator MALONE. I may ask at this point if they are authorized to do that before any action is taken by the Office of Defense Mobilization? I am directing this to General Metzger now. Can the General Services Administration take action in pilot plants without further action by the Office of Defense Mobilization, since they have been authorized to increase their contracts? Can they investigate and put up money for pilot plants on processes that have not been heretofore proven?

General METZGER. I believe they can, Senator Malone. I am not thoroughly familiar with the policy which has been provided GSA by ODM. However, I believe they may proceed with the support of pilot production if the analysis indicates that it is worth while, the analysis which is made for GSA by the boards and groups that were mentioned in the testimony of Mr. Ford. I believe they could proceed.

Senator MALONE. I have not yet had any information that the GSA is itself equipped to do very much of anything in determining processes or the feasibility of such processes. Do you think they are?

General METZGER. I do not believe that GSA proposes to be technically qualified, and for that reason calls upon the Metals and Minerals Advisory Board for evaluation of projects and processes which are submitted for financing.

Senator Malone, I think that is the procedure which GSA is following.

Senator MALONE. Apparently with the kind of boards they have, a considerable time elapses; is that true?

General METZGER. From the information which has been submitted in the testimony, I believe it is very time-consuming.

Senator MALONE. We are waiting now to hear from Mr. Mansure who has just recently taken office. I have an idea from his testimony this morning that he will really make an investigation of what has been going on.

General METZGER. I am sure he will, sir.

Senator MALONE. I think that is all, and we are very appreciative of your coming here, and would be interested in keeping abreast of your progress, if you saw fit to drop a note to us when you make such progress.

Mr. GOODRIDGE. We certainly will, Senator.

Senator MALONE. Thank you.

Mr. GOODRIDGE. Thank you, sir.

Senator MALONE. Mr. Leo Harvey. We have heard Mr. Harvey once before, but if he has any new information for the committee, we would be very happy to have him appear again.

FURTHER STATEMENT OF LEO HARVEY, PRESIDENT, HARVEY MACHINE CO., INC., TORRANCE, CALIF.

Mr. HARVEY. Thank you, sir.

Senator MALONE. Mr. Harvey, I note you nearly always have that piece of angle iron with you. Is it a new kind of angle iron, or do you just carry that in defense?

Mr. HARVEY. That is a little different from the one that you saw the last time. We thought you wanted to see a different configuration. You saw the long one last time, and we thought you might be interested.

Senator MALONE. Mr. Harvey, the committee was interested in your process of extrusion of this material. It is the first time we heard about it as being a practical thing. While it is not the prerogative or intention of the committee to follow through each one of these processes, that is the job of the Federal departments, we want to find out what the Federal departments are doing. But in order to find out what they are doing, we want to hear the actual and potential producers. You are a potential producer. If you have some additional evidence from that which you gave us in Los Angeles, will you identify yourself for the record?

Mr. HARVEY. My name is Leo M. Harvey. I am president of the Harvey Machine Co., of Torrance, Calif. I reside in Los Angeles, Calif.

Before proceeding with what I have, I was going to apologize to you, Mr. Chairman, because my statements may be repetitious.

Senator MALONE. I think we can say without equivocation that the committee has established the fact that the production of titanium in volume is a must if we are to hold our own in national defense in the air. We have also established in the opinion of the chairman that it is a perfectly feasible operation to make this metal from materials that can be found and are found in the United States and Canada, and that any volume that is necessary within a very reasonable time can be

secured. But it is going to take a little work and a little foresight and a little interest on the part of the Government committees operating in this field.

If you would just proceed now, it does not make any difference about the repetition, if it looks like it advances the projects.

Mr. HARVEY. In my own and other previous testimony before this committee, it has been developed that the metal titanium which is relatively new in our economy has very important and necessary uses in the defense program of the United States of America.

Senator MALONE. I think we can go further and say it has been established that if we do not have it, and any potential enemy does have it, we may as well stay home.

CONTROLLED DISTRIBUTION

Mr. HARVEY. The limited availability of titanium has necessitated a controlled distribution of all its present production to consumers whose needs are determined to be most important to the defense. The development of its fabrication technology and uses has been retarded by the lack of supply for fabricators interested in determining the properties of titanium and its alloys as it pertains to the operation.

If the potentialities of this new metal are to be exploited for national defense, much larger quantities must be made available so that it can be used in the design of strategic end products. The aircraft producers have stated that titanium is a necessity in the construction of military planes with improved performance characteristics. Its value in the military program is not limited to aircraft construction.

It also has an important application in other ordnance equipment and to the Navy. Perhaps it is heresy for one such as myself, who has watched, and I hope helped, development of aluminum structurals for aircraft to talk enthusiastically of another metal. The fact is that the aircraft industry has arrived at a point where the inadequacy of present structural materials is a critical factor, limiting the performance of faster jet-plane aircraft, now in prototype and awaiting the production line.

While aluminum alloys of today are the best structural materials up to approximately 250° Fahrenheit, planes of tomorrow require materials that will withstand temperatures up to 700° Fahrenheit and higher in airplanes and considerably higher in engines.

As I pointed out last time, our company has met with engineers of every major airframe producer at their request to discuss the possibilities of providing titanium alloy sections for planes still on the drawing board. The aircraft industry estimated that it may require approximately—and I purposely say approximately because I can only guess what it may be—250,000 tons of titanium yearly.

Fifty thousand tons of this we can expect will be finished extruded shapes. It is now clear from the technical viewpoint that titanium extruded shapes can be made available.

I have an illustration of a common component of one of the planes in production today. This is a longeron. It was extruded in our plant and it is only one example of what can be done with titanium alloy.

Titanium, the newcomer in the structural metal field, has been with us a short time. However, it has already been accepted, and as I am always optimistic and confident about our country's ability to rapidly develop its production methods on a new material, I am certain that development of a great titanium industry will come about quickly. I want to amplify my remarks of some weeks ago and present to the committee certain information and data on titanium in aircraft jet engines and on ilmenite, the raw material of titanium.

With regard to aircraft engines, the high temperature generated today in our jet engines requires the use of stainless steel and other refractory metals. In many instances titanium could be used, and in fact would be desirable both as to serviceability and weight saving.

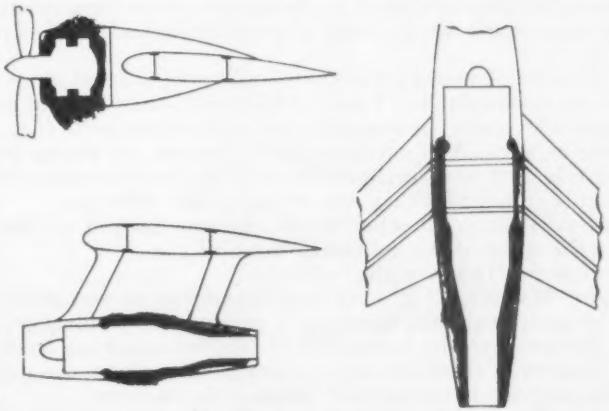
With your permission, Mr. Chairman, I shall pass copies to you and the members of the committee of an illustration of the source of heat affecting the design of an airplane engine.

The first sketch at the left shows heat radiated from a piston engine——

Senator MALONE. If you would like to submit this as an exhibit, it will be accepted and attached as exhibit No. 1 as part of your testimony.

(The chart referred to follows:)

ENGINE HEATING



Mr. HARVEY. As you will notice in the piston engine, the heat is contained and dissipated in the surrounding air without structurally affecting many parts in and surrounding the engine. In the partly mounted jet engines more parts are affected, and must be protected from the heat. However, the jet engine at the right not only heats the engine itself, but affects the major wing and fuselage structure all the way from the engine to the tail, as it shows in this picture in here.

I have in here a picture that we purposely got up for you, Mr. Chairman, and it shows a jet engine with the various components laid out, and shows where the heat effect will come.

Senator MALONE. We will accept this map and chart as exhibit No. 2 as part of your testimony.

EXHAUSTIVE TESTING REQUIRED

Mr. HARVEY. As we know, an engine manufacturer is always reluctant to place a new material into service without exhaustive testing. This is necessary because engine failure can occur in failure of one single small component part. Consequently, every engine manufacturer has been conducting tests for the past several years to determine the usability of titanium in engine components.

Indications we have received from engine manufacturers today show that in 1955 they could use 50,000 tons of titanium a year and an additional 50,000 tons in successive years thereafter until the minimum requirements of 250,000 tons per year was obtained. That is the minimum.

Senator MALONE. What would be the year you peg as requiring 50,000 tons?

Mr. HARVEY. 1955. They would produce it in 1954 if they could get it.

Senator MALONE. They could have used it now if they had it; is that true?

Mr. HARVEY. Yes, sir.

Senator MALONE. You think, however, that is about as fast, in your judgment, as they could use it in the engines and in the airplane manufacture under our present system of preparation and speed of preparation?

Mr. HARVEY. I would not say you could even use that much because you do not have enough. I am only going by what the engine manufacturers who make the tests and determine what parts they can use titanium in, say. As I explained to you before, an engine manufacturer is reluctant to place a new material into service unless it is very thoroughly tested, and they are testing it day after day.

Senator MALONE. In other words, we are delayed in the testing because the material has not been available?

Mr. HARVEY. That is right.

Senator MALONE. If it were made available, as you think it now could be made available, if emphasis were put on production, do you think the test could be made, and in 1954 we could use 50,000 tons?

Mr. HARVEY. I think the engine manufacturers are more acquainted with the program to answer that question than we are.

Senator MALONE. You heard what Mr. Hurley said this morning.

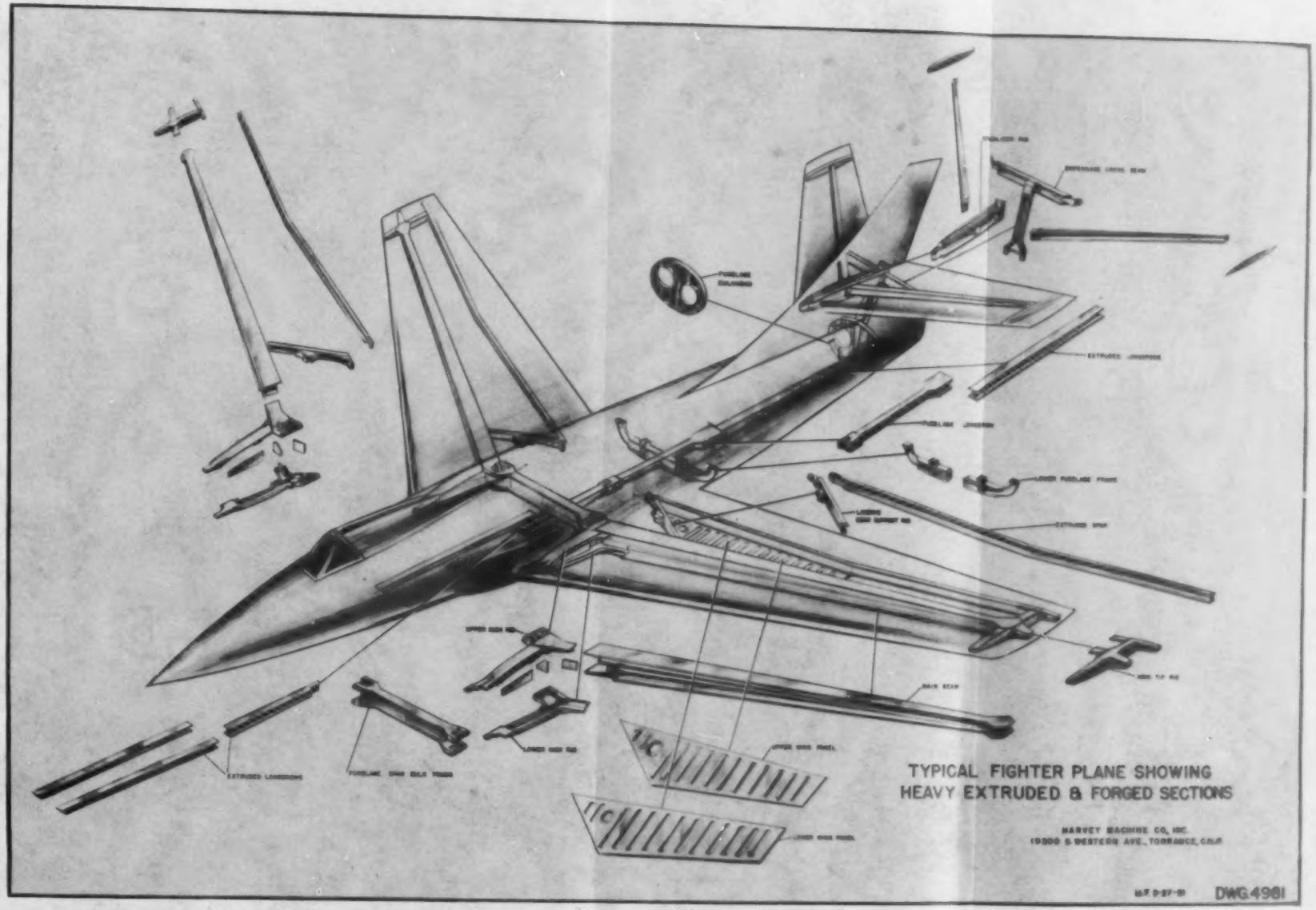
Mr. HARVEY. I will leave it for him to decide the time that he needs it badly.

Senator MALONE. I think he was ahead of you in his estimate.

Mr. HARVEY. That is right.

Senator MALONE. We realize they are estimates. The evidence piles up that we could use practically any amount up to 150,000 to 200,000 tons a year within a very reasonable time if they knew that it would be available and could just start designing engines and planes to use it.

Mr. HARVEY. That is right.


TYPICAL FIGHTER PLANE SHOWING
HEAVY EXTRUDED & FORGED SECTIONS
HARVEY MACHINE CO., INC.
DWG. 4981

Senator MALONE. Is that right?

Mr. HARVEY. That is right.

Senator MALONE. Go ahead.

Mr. HARVEY. The advancement in technology has been such that in every case titanium and its alloys are being incorporated in our newest and most efficient engines. We can expect that with increased development and because of volume every component made of titanium that will replace a component made of steel reduces the weight approximately one-half. Therefore, the use of titanium will be a must in our future engines if and when titanium availability can be assured.

I am further informed that in one of our newest engines a weight saving of 250 pounds can be made by the substitution of titanium for steel in the low-pressure compressor section alone.

Senator MALONE. Did you hear the testimony of Mr. Hurley that you save about 3,000 pounds per engine in the newer engines?

Mr. HARVEY. That is right. It is reliably recognized that it takes about 9 pounds of airframe to carry 1 pound of excess weight. To carry this 1 pound of excess weight, it is estimated to cost from $20 to $100, but in one aircraft company it costs $60. In other words, irrespective of today's high cost of titanium, every excess pound eliminated from an airplane by substituting titanium may save as much as $100, and on the average about $60 in the cost of an airplane.

Senator MALONE. That would mean that even at the present cost, they would use whatever was available.

Mr. HARVEY. That is right. It is apparent that our planes cannot truly become more efficient with the use of titanium but that cost savings can be realized even at today's high price for the metal. From this single example of the use of titanium in aircraft and jet engines, and from the testimony of many others, it is clear that a demand for this new metal is still growing. In order to supply this growing demand it is important that we be prepared to encourage and perhaps at the outset to nourish a healthy domestic titanium industry. To date the methods used for producing titanium have been rather costly. This is inherent in the development of any metal. As producers gain experience I am certain that more economical methods will be found, and the cost of titanium metal will correspondingly decrease.

Along with development of titanium metal technology there must be a careful and thorough examination of this country's titaniferous ores. The naturally occurring material from which titanium tetrachloride and titanium metals are produced is largely contained in the mineral called rutile. To date no large deposits containing this mineral are known in the United States or in the Western Hemisphere. Yet there are large quantities of the element titanium deposits in the United States. It occurs abundantly in the mineral ilmenite. This mineral is also the source of titanium pigments for use in paint.

There are undoubtedly large quantities of ilmenite available in the United States of America. It occurs quite frequently in certain sands. However, the small demand for titanium metal until the last few years has not been conducive to extended exploration for high-grade deposits of titanium-bearing ores in the United States. A program for ore exploration and delineation is the first requirement.

This is extremely important, Mr. Chairman. Unless we have ample supplies of domestic titanium ore available, we may be seriously hampered in the use of titanium for defense purposes if there is a world emergency and foreign sources are cut off, as they were in World War II.

Before World War II the major portion of titanium-bearing ore came from India and Australia. Only within recent years have other sources been developed on the North American Continent. Extensive deposits are being exploited in New York, Florida, Virginia, and North Carolina.

Ilmenite is also being produced as a byproduct of an operation in Idaho, and most recently the largest source of the mineral on this continent has been opened up in operations at Allard Lake in Quebec, Canada.

This ilmenite is used almost exclusively in obtaining titanium for paint pigments.

Senator MALONE. Would you say at that point, Mr. Harvey, that there is any difficulty in finding enough ilmenite ore on this continent to serve the industry?

Mr. HARVEY. I do not think so. We even find ilmenite ore next to Los Angeles in the hills of San Gabriel Mountains. There is a report by the Bureau of Mines of large deposits near the Hunter Pass.

Senator MALONE. Is not one of the advantages of this material the fact that there is known to be an ample supply of the necessary raw material in the North American Continent, and probably in the United States?

CANNOT RELY ON IMPORTS

Mr. HARVEY. There is one more point that I am going to come to, Mr. Chairman, and if I read it through, you will see what I am driving at. In view of the strategic importance of this metal, it is necessary to compress the technological development of its minerals, its production, its fabrication, and utilization into a few years so that it will be available when needed. Obviously we cannot rely on raw material that must be imported from across any of the major oceans. The titanium tetrachloride now used is produced largely from imported rutile. Almost all the producing companies are working on producing titanium from ilmenite. No commercial process for such production has yet been produced.

Senator MALONE. Mr. Harvey, you have touched on a very important subject there that is of general interest. For 20 years we have been urged in this Nation to save our raw materials and to import such materials from foreign sources. Now many of you have testified, including General Metzger of the Air Force, that probably we could be cut off from these raw materials, whether it be raw materials for titanium, raw materials for steel, like manganese that we now get eight or nine hundred thousand tons per year from India, and many other materials that are included in the 77 materials that this committee is investigating.

We are ordered by the Senate to determine availability of these materials in wartime. There would be no more difficulty of getting titanium materials than there would, we will say, manganese from India, would there? They are all in the same category.

Mr. HARVEY. There is another important feature, Mr. Chairman, and here is the greatest feature of the whole thing. Since titanium production is in the development stage today, it is vital for our domestic titanium industry that emphasis be placed upon developing a production process built around domestic ores available here. That is important.

Senator MALONE. You do not agree, then, with the general conclusion that has been followed for so long here that we have none of these materials, that we must save what we have and get everything from foreign nations?

Mr. HARVEY. Not from the information I have received on titanium, not from the information that the Bureau of Mines has, not from the information I can obtain from any other place.

Senator MALONE. There is no history that the Bureau of Mines was seriously considered in this business of determining what we have in the United States. This committee is consulting the Bureau of Mines, and I agree with you that they are the real authority. You may proceed.

SUGGESTS PROGRAM

Mr. HARVEY. Now that we know some of the properties of this metal, we can no longer afford to permit anything but its very rapid development. We must have a program as follows:

(a) Promotion of titanium mineral exploration and recovery;
(b) Research on production of titanium;
(c) Development of titanium alloys; and
(d) Methods of fabricating titanium.

No one can detract from the large part the Government has had in developing the titanium industry. The basic features of the present production process were developed and demonstrated by the Bureau of Mines. Existing and planned production of titanium metal was promoted by the establishment of expansion goals in the defense agency.

We must give credit to the Air Force and its forward-looking Secretary and able Assistant Secretary for Materiel who deserve credit for encouraging development of titanium alloy fabricating technique. Credit also is due to the Chief of Production and Resources Division of the Air Force who in carrying out Air Force objectives has been most vigilant in furthering development of titanium in all its forms for aircraft requirements.

It is essential for the United States to have a titanium program of wider horizon than the presently planned expansion goal for an annual output of 22,000 tons in 1956. I believe we can attain self-sufficiency in titanium and a defense machine equal to none if private enterprise and Government join in a realistic assessment of development of the technology of titanium around domestic materials.

Senator MALONE. You keep referring to the domestic materials. I judge you consider that vital.

Mr. HARVEY. Yes; I do.

Senator MALONE. You heard the testimony today and you heard the testimony in Los Angeles from the airplane-producing companies. The committee took time out to go to Los Angeles because we could get Lockheed, Douglas, Boeing, and other lesser companies at one hearing without interfering with their time schedule.

Would you give the committee in a few words your judgment as to what we could efficiently utilize in tonnage of titanium if it were available and the designers could just forget the availability, the same as they do now with steel and aluminum, and start right out tomorrow?

Mr. HARVEY. I have stated in here that in the airframe industry we estimate they could use immediately, if it is available, 250,000 tons.

Senator MALONE. Annually?

Mr. HARVEY. Annually. The same can be said about our engine industry. It is the same thing. As a matter of fact, it might be more vital and more important.

Senator MALONE. You think the same amount?

Mr. HARVEY. Yes.

Senator MALONE. About 500,000 tons if you could just forget the availability.

Mr. HARVEY. That is right. That is not touching any requirements that the Navy may have for ships, for the chemical industry. For instance, right now we are developing certain things for the Navy which are classified matters. It would help a great deal if these items could be made from titanium.

Senator MALONE. Is there anything in the chemical or salt water that has to be free from corrosion that would be very advantageous?

Mr. HARVEY. Very much so.

Senator MALONE. You are talking about the present price of titanium?

Mr. HARVEY. I am. I do not think the present price scares me at all. I want to mention an example.

Senator MALONE. Either in commercial or war planes.

Mr. HARVEY. It would not grow as fast as it would if the prices were reduced. The more we make the further prices go down—lower and lower. If we have a number of concerns competing with each other, we find that each one will see to it that it gets the business, and the price will go even lower. I believe that in the United States of America we always find new methods and ways of doing things. We have always done it so far, and we will do it again.

Senator MALONE. Mr. Harvey, as to the matter of how fast it would be used, I think you agree with practically all the other witnesses that it is just the nonavailability of the material that ails us. Where do you think we would be headed within the next 5 years without titanium in our planes, 5 to 10 years from now, if our potential enemies had it available?

Mr. HARVEY. It would be blasphemy to say it, but I would say we would be a second-rate nation.

Senator MALONE. Were you here yesterday?

Mr. HARVEY. Yes; I was here half a day.

Senator MALONE. The testimony showed yesterday that we sent samples to Austria of our material. I presume they are still not very far from Russia.

Mr. HARVEY. Yes; I know it is pretty close.

Senator MALONE. Would you approve giving samples of your material that you wanted to keep ahead of a potential enemy in the manufacture, giving them samples?

Mr. HARVEY. Definitely not.

Senator MALONE. Mr. Harvey, do you have a further statement to make?

Mr. HARVEY. That is all I have, unless you have any questions.

Senator MALONE. You have answered my questions, that it is a must material, and you could use a half million tons a year whenever it is available. Is that what I understood you to say?

Mr. HARVEY. That is right.

Senator MALONE. Describe this material you have in front of you.

Mr. MOUDRY. My name is G. A. Moudry, chief metallurgist of the Harvey Machine Co. This was developed partially, this section totally, in conjunction with the Air Force under General Metzger's group. Our problem was to extrude titanium, which supposedly could not be done. In the production of an aircraft, and in the structure of the aircraft today, we tie it together with extrusions and forgings. Forgings and extrusions are being made. This section was extruded in three of the toughest alloys today.

Senator MALONE. What material does it include?

Mr. MOUDRY. That particular section is chromium and aluminum, 92 percent titanium. That smaller section there was machined from a section like this [indicating]. It has a tensile strength of over 150,000 pounds per square inch.

Senator MALONE. Pounds per square inch.

Mr. MOUDRY. Yes. It is actually a structural part of the plane now. There are four pieces holding the tail onto the T–33. In that section over there showing how the hot gases pass through, you have to have a steel or titanium structure to withstand the heat in today's trainer.

This trainer was designed before the Second World War. Today that section is produced by rolling stainless steel in two sections and putting doublers on the top and bottom to make a taper. By going to a stainless steel extrusion in a form like that they get a higher efficiency in the section and save 3 pounds per piece. This was produced in titanium to see what would happen. It is this section machined down here, with no finish added to it. They can save 40 percent more in the section by using titanium. The section is so valuable that they are going to the Air Force to ask if they can put that shape on today's trainer plane.

That is a typical section that will be produced, that and forgings, in airplane structures of tomorrow.

Senator MALONE. I understand from your testimony that you would have no difficulty turning out any number of such shapes or as a matter of fact, any practical shape that might be desired.

Mr. MOUDRY. That is correct.

Senator MALONE. By the extrusion method.

Mr. MOUDRY. That is correct.

Senator MALONE. I think you have contributed more to the committee even than you did in Los Angeles. Thank you very much, Mr. Harvey.

Mr. HARVEY. Thank you, sir.

Senator MALONE. If you have anything further to offer, you may send it in.

We have Dr. A. B. Kinzel, of the Union Carbide & Carbon Corp. Dr. Kinzel, we have all heard about Union Carbide. We have all heard from hearsay and reading the paper about the material they turn out. They are a very efficient company, and have been over

the years. Would you identify yourself for the record? You know the objectives of the committee. Will you give us any information that you think will be helpful.

STATEMENT OF AUGUSTUS B. KINZEL, PRESIDENT, UNION CARBIDE & CARBON RESEARCH LABORATORIES, INC., AND VICE PRESIDENT, ELECTROMETALLURGICAL DIVISION, UNION CARBIDE & CARBON CORP.

Dr. KINZEL. I am Augustus Kinzel, president of Union Carbide & Carbon Research Laboratories, Inc., and vice president of the Electrometallurgical Division of the Union Carbide & Carbon Corp.

We have been interested in titanium in one form or another for decades. In 1940 we hired Dr. Kroll, who came over from Europe at that time. He worked in our laboratories for 5 years. He had the process on a laboratory scale at that time.

Senator MALONE. Who was Dr. Kroll, for the record?

Dr. KINZEL. Dr. W. J. Kroll is a Luxembourger.

Senator MALONE. You are talking about Kroll?

Dr. KINZEL. K-r-o-l-l, the famous Kroll of the Kroll process that we have been hearing about in connection with titanium.

That same Dr. Kroll worked for us for 5 years and left us to join the Bureau of Mines. The parting was amicable and pleasant. He left us because our appraisal of his process indicated that it was not ready for a financial civilian venture at that time.

We have continued to experiment on titanium metal production, research of both the fundamental variety and applied. We have been interested in processes developed by others. We have investigated a great many and taken options on some.

About 2 years ago, perhaps somewhat longer, a representative of DMPA came to us to know whether we would help in providing titanium sponge. We explained at that time we were not ready to do so, but would advise DMPA when we were. We have been working diligently on a very particular process conceived by our own people, and have gone through the 1-pound scale, 5-pound scale, 100-pound scale, and 500-pound scale. When we reached that stage, we then did advise the successor to DMPA that we were in a position to talk to them about supplying metal.

All this, by the way, was done with our own money and it was not held up for lack of funds at any time. At the present time we are constructing a prototype unit which we expect to be completed very early next year.

SUPER PILOT PLANT

Senator MALONE. What do you call a prototype unit?

Dr. KINZEL. It is a super pilot plant, if you will. Perhaps let me put it differently. It is a pilot plant which is much more akin to an individual unit of a large plant, than the smaller pilot plant would be. Our process comprises the sodium reduction of titanium tetrachloride. It has been stated that the making of titanium metal is a difficult proposition. It is. I would like to emphasize the difference between feasibility and practicability in the making of titanium sponge or crystal.

There are dozens of processes that are feasible. To be practicable one must have a process that can be engineered in such a way as to insure uniform product of high quality day in and day out. The quality of the material that we have been making has been between 145 and 155 Brinell. We think we can do better. But as I stated to the special committee already referred to, in view of the experience of others in going from large pilot or even prototype to production, we would not be willing at this minute to guarantee the quality better than now required, even though we might expect to produce it that way.

When we were ready, which was some 6 months ago, we advised the successor to DMPA, and then on October 19 appeared before the Frary committee and told our story with respect to the development and the stage at which we were. The stage at which we were was that we were prepared to recommend to our management that we build a plant to produce 10,000 tons a year with our own corporation money, asking nothing of the Government except that we did require some assurance as to the fact that there would be a use for the output of the plant, assuming the output met specifications, of course. There has been discussion along those lines since then, as yet inconclusive.

Senator MALONE. What kind of a contract have you requested for such guaranty?

Dr. KINZEL. Primarily a firm purchase contract for 20,000 tons of material.

Senator MALONE. Per year?

Dr. KINZEL. No, just total. Ten thousand-ton plant and just a firm contract for 20,000-tons purchase.

Senator MALONE. At what price?

Dr. KINZEL. At the present current price of $5.

Senator MALONE. You would turn out sponge material?

Dr. KINZEL. Sponge or crystal. It is a matter of definition.

Senator MALONE. But it would be per pound for the sponge or crystal material?

Dr. KINZEL. That is right, material ready to be remelted.

Senator MALONE. No advance money from the Government?

Dr. KINZEL. No advance money from the Government.

Senator MALONE. What kind of a reception did you get?

Dr. KINZEL. As I say, as yet the response has been indecisive.

Senator MALONE. How long have you been discussing the matter with GSA?

Dr. KINZEL. In detail since October 19, and on a broader basis before that.

Senator MALONE. What would this plant cost you to build, equip, and start production?

Dr. KINZEL. As an estimate, approximately $35 million.

Senator MALONE. Which you would furnish yourself?

Dr. KINZEL. Which we would furnish.

Senator MALONE. At $5 a pound for the amount that you want the guaranty for, what would be the total amount of money?

Dr. KINZEL. Two hundred million dollars worth of material. I might add that we were perfectly willing to consider modifications involving amortization of the plant for any portion of this 20,000 tons that they did not see fit to purchase in the future for one reason or another.

Senator MALONE. What you are offering the Government then is a guaranty of quality desired by industry and a definite amount of titanium at a certain date.

Dr. KINZEL. That is right.

Senator MALONE. At the price they are now paying and gambling on.

Dr. KINZEL. That is right, sir.

Senator MALONE. If I were just judging from a distance I would say that is the best offer they have had.

Dr. KINZEL. We feel we have come a long way in our engineering and development and have a sound basis on which to take such an offer.

Senator MALONE. In other words, they risk no money until they get the material.

Dr. KINZEL. That is right.

Senator MALONE. The only risk they take is that it may be cheaper by some other process by the time you are in production.

Dr. KINZEL. That risk, plus the other risk that for some reason or another not apparent, there may not be a use for the material in which case they would stockpile it.

Senator MALONE. I might say from the evidence we have had from three hearings that there was very little gamble that you will not need all the material you can get at that time.

Let me ask you again, what would be the date of your going into production if you had the contract tomorrow?

Dr. KINZEL. Two years from the time of the contract.

Senator MALONE. And then 2 years production from then?

Dr. KINZEL. That is what would be concerned. Presumably that, or there might be some modification of that. As I stated previously, we were talking broadly 20,000 tons.

Senator MALONE. Was there any other provision in this offer, that is, something like a certain amount of margin per pound if they did not take delivery of the metal?

Dr. KINZEL. Yes. That is what I referred to a moment ago where I said a modification whereby if they did not take this material, they could pay a certain number of cents per pound for that which was not taken in order for us to amortize the plant.

Senator MALONE. Would you care to testify to that?

Dr. KINZEL. If I remember, that came out to 85 cents a pound if the plant finally costs us the $35 million predicted. But this would be modified in line with the cost of the plant.

Senator MALONE. In other words, if they wanted to close out the contract, and not take any titanium at all, they could give you 85 cents per pound, and that would be the cancellation clause.

Dr. KINZEL. Yes. Another way of stating it might be that they would pay amortization for——

Senator MALONE. What would that amount to in actual money?

Dr. KINZEL. If they did not take anything, it would amount to $35 million. It was based on that.

Senator MALONE. That is the gamble they are taking, and no gamble at all if your product does not meet specifications and is not delivered on time.

Mr. KINZEL. If our product did not meet specifications and is not delivered, the Government has no gamble.

Senator MALONE. They are waiting for a better offer apparently.

Dr. KINZEL. Overall it is a continuous process; yes. I might add primarily because originally we had been requested to do so.

Senator MALONE. Your testimony, I think, is very helpful to the committee. At least it shows that a very responsible company is willing to gamble its own money in the production of the metal at the present price. I think that is very, very helpful testimony. We thank you very kindly.

If you have anything at any time to offer the committee, will you submit it in brief form to the committee?

Dr. KINZEL. Yes, sir.

Senator MALONE. Thank you.

Dr. KINZEL. Thank you, sir.

Senator MALONE. Before you go, I might say I thought you had testified that your process is a continuous process.

Dr. KINZEL. It is broadly continuous, but has one batch step therein. One discontinuous step in it.

Senator MALONE. But at the end it is a continuous process?

Dr. KINZEL. Overall it is a continuous process; yes. I might add that this business of continuous or discontinuous process is among other things something of a matter of definition. In the metallurgical world at large, many of our processes are continuous for the most part with a few discontinuous steps therein.

Senator MALONE. I do not think the committee is too much interested as to the process. It would have to be a satisfactory process. It is the quality and the amount that is apparently worrying everybody now.

Dr. KINZEL. If it were not satisfactory from the standpoint of quality, I can assure you we would not think of risking our money this way.

Senator MALONE. Your company being a very successful company in a financial way, the reason you are going into the business, and the reason you are interested in it in the first place is to pay dividends to stockholders, just like any other sensible company.

Dr. KINZEL. We are interested in the metals business.

Senator MALONE. You are interested in this because it is a new field and by getting in that early, you feel you can be a competitor.

Dr. KINZEL. That is correct, and add to that that the largest part of our business is winning metals from ores.

Senator MALONE. Just speaking as one member of the Senate, I am glad you are interested in this. It means that substantial people are interested in the metal and it means there is a future in it, or you would not be interested in it.

Dr. KINZEL. Yes.

Senator MALONE. Thank you.

Dr. KINZEL. Thank you.

Senator MALONE. Is Mr. Gerdan of the Allison Division of General Motors here?

STATEMENT OF DIMITRIUS GERDAN, CHIEF ENGINEER, TURBOJET ENGINES, ALLISON DIVISION, GENERAL MOTORS CORP.

Mr. GERDAN. Yes, sir.

Senator MALONE. You have heard the testimony generally and you know the objectives of the committee. You may proceed in your own way. Do you have a prepared statement?

Mr. GERDAN. I will read portions of it. My name is Gerdan; I am chief engineer of the turbojet-engine activity of the Allison Division of General Motors Corp. I brought with me Mr. J. L. Goldthwaite, who has headed up the critical materials engineering activity for the same division.

I will read a portion here of a prepared statement, which I will send later to the committee.

Titanium and its alloys are light and strong, leading to reduction in weight and improvement in performance of aircraft gas turbine engines. Its relative immunity to corrosion simplifies many design and maintenance problems and leads to savings in strategic metals.

Of those various advantages, weight reduction is by far the most important. Present disadvantages are its scarcity and high cost, difficulties of fabrication, deficiencies and irregularity of quality of the current alloys, and the economic waste due to inability to reclaim scrap.

These are purely temporary problems which now impede progress, but they will largely disappear with greater experience. We have had the benefit of centuries of experience with ferrous alloys and 1 or 2 generations with magnesium and aluminum, whereas the sum total of experience with titanium metals covers roughly about 10 years.

In comparing titanium with steel, the present strong titanium alloys are as strong at moderate temperatures as most of the heat-treated alloy steels used in engine construction. They weigh only six-tenths as much as steel. The same ratio holds between the soft unalloyed grades of titanium and the milled steels.

Therefore, many steel parts can be converted directly to titanium at no sacrifice in strength, and with a 40-percent savings in weight. In comparison with aluminum and magnesium, titanium is 2 to 3 times as strong as our finest grades of aluminum alloys.

Senator MALONE. That is for the same weight.

Mr. GERDAN. In this case it weighs less than twice as much comparing it strictly on a physical property basis. Again these same strength ratios hold between the soft grades of titanium and the softer grades of aluminum and magnesium.

The opportunities for direct substitution of titanium for magnesium and aluminum in current turbine engines are relatively few and unimportant at the present time. These are going to be important, however, in the future when the higher operating temperatures arising from transonic and supersonic flight obtain in engines. The strength of pot aluminum and magnesium fall off very rapidly with increases in temperature.

For example, the very best aluminum and magnesium alloys retain half their room-temperature strength at about 400° Fahrenheit, and are practically useless above 500° Fahrenheit. Many of the steels are useful up to 1,000° Fahrenheit, and some of them at higher temperatures. The present titanium alloys, those actually available for use, retain half strength up to about 800° to 850° Fahrenheit, and are comparatively weak at 1,000°.

So you see that titanium fills that gap of 400° to about 850° that neither aluminum nor magnesium will handle. It will fill that gap at 40 percent less weight than steel for the same purpose.

WEIGHT SAVING IMPORTANT

We understand there are new titanium alloys in the pilot stage which promise to raise the temperature limits by another 100° to 200° Fahrenheit. We also understand there is comparatively little prospect of usefulness above 1,000° Fahrenheit. The prospects for usefulness where strength is an important factor are good. If we look at the aircraft gas turbine engines, say the turbojet and the turbopropeller engines, we will see that with the currently available materials, the most important applications of titanium arise in the compressor section, or what has been referred to as the cold section of the engine. In a particular engine which has been studied the compressor rotor assembly was approximately 900 pounds as made of steel throughout. Converted essentially 100 percent to titanium, it would weigh approximately 570 pounds, or a direct weight saving of around 330 to 340 pounds.

This particular weight saving of itself is quite important, but there are also some further indirect savings. This rotor must be supported on hearings which must be supported in housings and so on, and under the various loads that are applied to an engine during maneuver in flight those loans are taken out through these supports and whatnot, so if the rotating element itself is lighter, those support members in turn can be lighter. There are other uses throughout gas-turbine engines for titanium, and we might just rather rapidly summarize those by stating that in my opinion any way, and those of my associates, it appears that approximately 20 to 25 percent of current turbojet engines of a total finished weight of such an engine could be used as titanium.

I think some figures somewhat higher than that have been given, but this is our particular estimate with currently available alloys. If we look at that in terms of, let us say, World War II experience, I believe our peak production in any one year of engines, in this case purely piston engines, engines of 1,000 horsepower or more, was around 100,000 units. Those engines would be used both in combat aircraft and in the supporting transport aircraft. Let us say now we are interested in building 100,000 turbojet engines a year, and let us just for the sake of this particular analysis assume that each engine weighs 3,000 pounds in the conventional materials.

Now let us assume that 20 percent of each engine can be built out of titanium parts. In other words, 600 pounds of finished engine weight would be made of titanium.

Let us also assume that for each pound of finished engine part we need 4 pounds of mill stock, forgings, and so on. So each engine would then consume 2,400 pounds of metallic titanium, converting back to sponge, which we understand that there is about a 60-percent recovery of sponge in the mill product; that means 4,000 pounds of sponge would be required per engine, or 2 tons per engine. At 100,000 engines per year, that is 200,000 tons of sponge.

Senator MALONE. The number of engines you are considering there is the number turned out by all the engine manufacturers.

Mr. GERDAN. Yes, sir. That is engines of a category that would be used in combat aircraft and supporting transports. No trainers are counted in that at all, or liaison aircraft.

Senator MALONE. About 200,000 tons in the main construction field of the engines for aircraft purposes.

Mr. GERDAN. This is turning out finished engines. Actually the figure is quite a bit larger than that. If we assume now we have 100 percent spare parts, the figure becomes 400,000 tons. All of this is taken without scrap recovery being considered. In other words, you need 400,000 tons of sponge, assuming that scrap recovery does not exist.

Senator MALONE. It does not exist now. We understand that there has been quite a bit of progress made recently.

Mr. GERDAN. It points out the importance of developing methods of reclaiming scrap. It is highly essential that be done. A little earlier this morning, I believe, someone mentioned the cost of weight in an aircraft. Last evening we sat down with Mr. E. A. Schmued, who is vice president in charge of engineering of Northrop Aircraft, and who is remembered best in the industry as having been responsible, if any one man can be called responsible, for the design of the F–51 in World War II, and the F–86, which played such an extremely fine part in the Korean war. We estimated last night that if we would take a modern high-performance, twin engine aircraft weighing 100,000 pounds, and having certain performance characteristics, and further we assumed it had 2 powerplants of 5,000 pounds apiece, or 10,000 pounds total weight. If we made a 20-percent saving in the weight of each engine, or a total saving of 2,000 pounds in engine weight, that aircraft then for equal performance and equal quality could be built for an all-up gross weight of 88,000 pounds. The 12,000 pounds saving is in the all-up gross weight of that particular plane. That is not a figure that should be used generally, because the weight savings that can be accomplished in an airplane depend first on the basic mission of the aircraft, its initial design characteristics, its powerplant, and so on and so forth.

Senator MALONE. What you are telling the committee is that if the frame designer knows what the engine is going to weigh when he is at work, then he knows what he can save in the preparation of the aircraft.

Mr. GERDAN. He is going to make a lighter aircraft; yes, sir. In that particular case the aircraft weight is reduced by 12 percent, which means that we could get nine instead of eight aircraft.

Senator MALONE. That is very interesting. You are speaking now, I assume, on what is now considered practical through experiments if the material were available so you did not have to look back.

Mr. GERDAN. If it were available and if we knew just a little more about it. Knowing a little more about a material is again like the old saw about the chicken and the egg. If you have more material, you can find out more about it.

Senator MALONE. It would not take you long to learn about it if you had plenty of it.

Mr. GERDAN. I do not believe so. We have learned quite a bit about it with the extreme scarcity of the material.

Senator MALONE. In other words, it is comparable to getting out of the pilot-plant stage and the manufacture.

FULL USE IN 1957

Mr. GERDAN. That is right. We are not ready to use it on a large scale. However, it would not be too long before we would be ready to use it on a large scale.

Senator MALONE. If you had plenty of it available, what would be your estimate of time until you were making full use of it?

Mr. GERDAN. I would say that we could consider using it in every engine that we build during the latter part of 1956 and fully in 1957.

Senator MALONE. If it were available very soon?

Mr. GERDAN. If it were available very soon.

Senator MALONE. And you can be assured it would be available in quantity within a reasonable time.

Mr. GERDAN. We would have to have more available for our own testing purposes. I believe one of the things that should be done is to build a certain quantity of engines in the industry for service tests by the Air Forces. A quantity of about 200 could be used to obtain greatly needed service history. The quantity mentioned above would be the total supplied by several engine manufacturers.

Senator MALONE. But that is all dependent on getting the material?

Mr. GERDAN. That is correct.

Senator MALONE. Where do you get your material now?

Mr. GERDAN. We have obtained our material from Rem-Cru and some from Titanium Metals, I believe. Frankly we have not used too much of that. Most of our material has come from Rem-Cru.

Senator MALONE. Thank you. Go ahead.

Mr. GERDAN. This exhibit might show the relative size of pieces. The largest piece made yet to date is a compressor disk forging. You can see that comparing with that man. We have run the gamut of sizes in between.

Senator MALONE. Would you like to present this as an exhibit?

Mr. GERDAN. We will send that as part of our brief and photographs of our blades also.

Senator MALONE. When received it will be made a part of your testimony as an exhibit.

(The information was not furnished at the time the hearings were printed. When furnished it will be included in the committee files.)

Mr. GERDAN. I would like to add one thing to the various recommendations that have been made today to encourage the development of titanium ore processing, the development of the metal itself. I think that this country should plan a sufficient titanium production so that a reasonable proportion of the metal can be diverted to civilian applications. I have been informed that the dairy industry, for one, could use large quantities of titanium for pasteurization equipment. The very finest of existing corrosion resistant materials are subject to considerable attack in the presence of milk. By making a proportion of the production available to civilian application, I think we will hasten the development of improved grades in a wider variety of alloys.

I think we have seen the same sort of thing happen with aluminum and magnesium, and there is a very close parallel in this case between this new material and those two previously "wonder" materials.

Today we have discussed its use for war purposes exclusively, but I would like to again reemphasizee that rapid development will be aided by civilian uses.

Senator MALONE. You have heard the testimony, and you are in the business of manufacturing engines, and no doubt know something of their actual use and their efficiency and their competitive advantages. Suppose our potential enemy were ahead of us in the production of such war material and war planes, and we were forced to compete in actual battle with the type of plane we are now turning out, what would be your judgment of the general results?

Mr. GERDAN. It would be somewhat like, shall we say, a welterweight fighting a first-class heavyweight. He might be able to buzz around and annoy him for a while, but if he ever got hit, it would be curtains.

Senator MALONE. Your judgment then, and you are in the business, is that unless we keep at least abreast of this business, and we certainly ought to keep ahead, then we better try to make some other arrangements instead of meeting an all-out fight.

Mr. GERDAN. You can never afford in military technology, as has been put several times today, to be second best. You cannot afford it.

Senator MALONE. There is no second best in an airplane squadron for very long.

Mr. GERDAN. No, sir.

Senator MALONE. That is the impression that the chairman of this committee has gained in the discussion of this material. Therefore, it has been rather hard to understand why with 3 or 4 years, realizing this to be a fact, that we are still talking about such small amounts of titanium, especially since we have all the raw materials in the United States and nearby areas in Canada that are necessary and have so many operators and producers that want to get in the business, and so many producers of the war and commercial planes from the engines to frames clamoring for the material. What would be your explanation of this delay?

Mr. GERDAN. In the early phases, and by early phases, I am covering the period approximately 1947 to 1950, those of us who must put the material to its end use did not know enough about it.

Senator MALONE. Three or four years ago.

Mr. GERDAN. That is right. We would receive small samples. They could be used for metallurgical laboratory investigations. Very few of them were of sufficient size even to do something like that with. Much must be known about a material before it can be used in engineering design. We must be able to depend upon uniformity of physical properties, quality, etc. in order to make successful application of a material. This was lacking.

The next phase was one of devoting much of our engineering effort to getting going for the Korean conflict. So instead of being able to assign our most able development engineers to the exploitation of this particular material, we again had approximately a 2-year period in which our top development men were more concerned with the development of existing engines and existing designs and so on. That is beginning to change, however.

Senator MALONE. That was one way of delaying our operations here.

Mr. GERDAN. Yes.

Senator MALONE. How long has it been since you have realized the potentialities of this material and its probable practical use?

Mr. GERDAN. We first became interested about 6 years ago. The first laboratory samples were obtainable in 1948. We have been making engine parts and testing them in one form or another for about a 3- to 4-year period.

Senator MALONE. Go right ahead if you have a further statement.

Mr. GERDAN. I believe we were speaking about various stages in the use of this material. Part of that period was also consumed in learning how to use the material. Most of our applications at first would use the material in the form of forgings. We had to develop know-how in working the material and subsequently machining. That part of the program has come along quite well, not only in our company, but in various companies throughout the industry. We have had to look at other phases, and I think this again is a factor that should receive careful attention—I am sure that General Metzger's people have been doing this—in the case of the very large forgings, there are a limited number of large hammers in the country that can turn out those forgings. There are also a limited number of large presses. As a result we and other users should turn our attention to other methods of fabricating those large forgings.

One of those methods unfortunately I do not think should be discussed here. However, General Metzger's people are completely familiar with it. I just want to use that to point out the need for using what may appear to be unconventional approaches in the working of the material.

We have to look at not only getting sponge, but these other things before we find a wide usefulness.

VITAL IN WAR PLANES

Senator MALONE. As I understand your testimony, Mr. Gerdan, you consider the material a must in future war planes?

Mr. GERDAN. Absolutely.

Senator MALONE. And very important in commercial planes.

Mr. GERDAN. Absolutely.

Senator MALONE. And you consider that there are no problems in front of you that cannot be properly adjusted if you have the material available.

Mr. GERDAN. I know of none that cannot be solved.

Senator MALONE. It is just like any new material coming on the market.

Mr. GERDAN. That is correct.

Senator MALONE. Then you would say that right now the emphasis must come from some place to emphasize that importance and to secure the material.

Mr. GERDAN. That is correct.

Senator MALONE. If I understand your testimony, there is little danger of overproduction in the next 2 or 3 years.

Mr. GERDAN. I would say there was little danger in the next 10 years.

Senator MALONE. Do you believe as many have testified that while the civilian use for this material is relatively unknown because it has

not been available, that probably a great amount of the material would go into civilian use almost immediately if it were available, and it is impossible to see the end, as far as maximum use is concerned?

Mr. GERDAN. That is correct. I talked with a supplier of dairy equipment not too long ago—just this last summer, as a matter of fact—and he stated that he had been approached by representatives of the dairy industry who wanted equipment made at today's prices for the material.

Senator MALONE. I was talking about today's prices.

Mr. GERDAN. At today's prices, they could use it in civilian work.

Senator MALONE. In other words, it eliminates replacement of material enough so that the price is no obstacle.

Mr. GERDAN. That is right.

Senator MALONE. Of course, if, as we hope, the price would come down through volume, which it always has in every other material, and you have heard the testimony that the price can be materially reduced and will be materially reduced when we are able to get into production, if it comes within 100 percent of the cost of steel and aluminum and magnesium, it would be your judgment, if I gather the right impression from your testimony, that the use would be almost unlimited.

Mr. GERDAN. Yes, I would say its use would be away beyond anything discussed today. I want to refer again to this dairy industry. I do not want to seem to be harping on that particular thing, but as I understand it, the materials used in the pasteurizing equipment today are those same alloys that we use very extensively in gas turbine engines. We have to see the significance of that. Those particular materials are materials that could find themselves in short supply in wartime. If we can substitute North American material for some of these that have in the past been brought from overseas, substitute a North American material for a civilian material essential to our economy, war or peace——

Senator MALONE. That is a civilian material where the raw materials come from foreign nations across the major oceans.

Mr. GERDAN. That is right, and if we could use these rich alloys that are now used in the dairy industry in our engines in wartime, we would be obviously better off all around.

Senator MALONE. You consider that as an item in your preparation for war, to have the raw materials available on this continent or in this hemisphere?

Mr. GERDAN. In our design work in trying to eliminate the usage of certain critical elements in the engine——

Senator MALONE. What are some of the critical elements? I am asking you because I am impressed with your testimony as an engineer.

Mr. GERDAN. The first of them I consider is to be human labor. That is the first and foremost. Then columbium, chromium, nickel, tungsten, molybdenum, cobalt, and in this particular case, titanium.

Senator MALONE. That would depend on the type of warfare we wage, and the number of men necessary. This committee has given that some thought, to. If you go into the air and under the sea, then it may not be necessary for mass land armies. As a matter of fact, one of the major nations has already indicated that they have no in-

tention of joining any land army outside of their own borders because it would be ineffective.

You would be interested, I think—it is already in the record—in a table which I am going to give you, prepared by the Bureau of Mines engineers. These engineers whose testimony will be available to you, which will be published, I hope, in the reasonably near future, have arranged a table containing titanium, ilmenite, titanium rutile. It is set up to show the availabiilty of these materials and the time element if the proper preparations are made in the United States proper and in the Western Hemisphere. You would be interested to know just roughly that we finally come down to the materials that would not be available in the Western Hemisphere if a commonsense program were initiated over a period of 3 or 5 years, to industrial diamonds. That considers the laboratory work, the replacements, substitutes and economy in materials and we have had testimony, very expert testimony of Dr. Oliver Ralston, whom I consider one of the most outstanding men in the world on known metallics, that you could cut the use of industrial diamonds probably in half through use of other metals now well known and practical.

We have also had some testimony, and will complete it, that probably industrial diamonds would be available if properly developed in the Western Hemisphere.

Would you be interested to know that is the only one left, and all of this propaganda and material that has been put out that we are a have-not nation and a have-not hemisphere, that we must get all of our materials from foreign countries and save our own—I referred to it on one occasion today—a character that is becoming rather well known.

It is a little late, but it is very interesting. This character by the name of White, presented a memorandum to Mr. Truman dated January 10, 1945, in which he recommended that we could safeguard and conserve our strategic-material reserves in postwar years, which are now at a minimum level, by importing from abroad to meet annual production requirements. It goes on to say that Russia has a tremendous reserve and we should get much of our material from that source, not bothering to explain to the President of the United States that if we become dependent on the foreign shore for such materials that probably submarines in any form of warfare that could prevent shipment of materials, could take care of us.

Also through that method we have become dependent now on a war economy just because of the imports that are coming from lower cost labor nations.

I will not say as a result of this memo, but it coincides with the memo dated January 10, 1945, on July 23, 1946, the President of the United States wrote a letter about our stockpile. It is a statement by the President in approving S. 752, the stockpile bill, that provided for certain considerations to domestic producers, making up the difference between the wage standard of living between here and abroad, not favoring them actually, but some kind of an adjustment so that they could buy domestic materials, and he says in this letter, following along the memo by Mr. White, that he wants it plainly understood that—

I have today signed the Strategic and Critical Minerals Stockpiling Act because it is important to the national interest that this Government have the power to

acquire stockpiles. It is only because of the overriding importance of this purpose that I am able to overcome my reluctance to sign a bill which reaffirms the application to stockpile purposes of the provisions of title 3 of the act of March 3, 1933 (47 Stat. 1520), known as the Buy American Act (1943)—

and it goes on to say that it is not the policy of the administration to follow the intent of Congress in this act and practically orders them to do something else.

That might be very interesting to you, because we have been following that idea for a good many years now and have just about got ourselves in a position so that we are dependent on offshore areas across one or both oceans for the material that you have testified you think should be produced here, and I certainly agree with your testimony.

Perhaps that had something to do with the United States Senate passing Senate Resolution 143, setting up this committee's work to determine the availability of these critical materials in wartime.

If you have any further information at any time that you would think would be helpful to the committee, you know its objectives, we would appreciate it if you would send us a brief.

Mr. GERDAN. I would be very happy to send it.

Senator MALONE. Does your associate have any further information to offer?

Mr. GOLDTHWAITE. I think not.

Senator MALONE. Thank you, and we certainly appreciate your appearance here.

Mr. GERDAN. Thank you.

Senator MALONE. We have Mr. Gwinn and Mr. McNamara, of Pratt & Whitney Aircraft.

Mr. Gwinn, you are familiar with the objectives of the committee, that this is only 1 material out of approximately 77 that we are investigating, but we found it very interesting, and we think a very necessary investigation, and have devoted more time to it than we originally intended.

If you have any information, either in the form of a written statement or an oral statement, that you would like to make, you may proceed.

STATEMENT OF WILLIAM P. GWINN, VICE PRESIDENT AND GENERAL MANAGER, PRATT & WHITNEY AIRCRAFT, ACCOMPANIED BY B. J. McNAMARA, PURCHASING MANAGER, PRATT & WHITNEY AIRCRAFT

Mr. GWINN. I have no prepared statement. I am William P. Gwinn, general manager, Pratt & Whitney Aircraft. I have no prepared statement. I will try to answer your questions to the best of my ability.

One thing I would like to say—and I hope nobody will take offense: I heard this afternoon some specific figures on weight saving with titanium for our engine, and those are classified. Whether we could warn the press people here, I think we should.

Senator MALONE. It was not the intention of the committee to have any classified information presented.

Mr. MOSKOVICS. Are you referring to my testimony?

Mr. GWINN. I think yours and Mr. Harvey's. I know the enthusiasm sometimes——

Senator MALONE. I am sorry. I think it is too late for that now. But every witness has been warned about classified information.

Mr. GWINN. I think I owed it to bring that forward, because we have been very conscious of it. We have been trying to get permission from the military services to talk more about it, and they have impressed upon us the importance of keeping weights and performance details to ourselves.

Senator MALONE. I expect as you say the enthusiasm about reaching such savings through the production of this material may be less thoughtful at the moment. I am sorry that it happened. I hope it does not happen any more. If you can give us any information for the benefit of the committee that would help us in our conclusions as to what should be done, what we should recommend to the Senate in regard to this particular material, it will be helpful. I hope by the time the report reaches the Senate, that we will be past the period and it will not be necessary for us to take any more action. But the progress to date has not been very encouraging.

Mr. GWINN. Pratt-Whitney Aircraft has done a great deal of work with titanium alloys in the development of the engine.

Senator MALONE. You have identified yourself for the record.

Mr. GWINN. Yes, sir. To put it mildly we are extremely enthusiastic about its possibilities, both present and future. We have a very real and immediate program for the use of the material in production and for a further very extensive use of it in development for the present engine to further make substantial weight savings, and for future models of our engines.

We submitted our requirements through the year 1957 of production needs, and it looks like our requirements can be met through about the second quarter of 1955. From there on out, there is some fuzziness whether or not there will be sufficient quantities of material to satisfy our needs.

Senator MALONE. What do you mean that your requirements can be met in 1955.

Mr. GWINN. No, through the second quarter of 1955, as we have projected our production needs.

Senator MALONE. Are you the only company that is going to have its requirements met, or do you think all of the companies in your business will?

Mr. GWINN. I can't speak on that, sir. I do not know.

Senator MALONE. I am sorry for the interruption. It was Secretary Talbott. He will appear Friday morning at 10 o'clock. It will be a public meeting but he will be the only witness as far as I know. We will try to get deeper into the Government end of this thing.

Go ahead.

Mr. GWINN. I think we were speaking about our needs last and we have forecast our requirements through 1957 and our supplier indicates that with propor allocations and things our requirement can probably be met through the second quarter of 1955.

Senator MALONE. Who is your supplier?

Mr. GWINN. Titanium Metals Corp. primarily.

Senator MALONE. That is at Henderson, Nev.?

Mr. GWINN. That is right.

Senator MALONE. They are producing 3½ to 3¾ tons per day of material. Testimony shows not very satisfactory as to quality. What do you require in Brinell hardness?

Mr. GWINN. I cannot answer that specifically.

Senator MALONE. Can your associate?

Mr. MCNAMARA. I cannot answer that question specifically, but I can confirm the fact that the material at the present state of the art varies considerably one piece as against another in that particular qualification. I do not think that is peculiar however, to our particular vendor but rather peculiar to the industry at that moment again because they are learning.

Senator MALONE. I do not understand that is true. I rather understand that the amount produced by the other company—that is in production on its own account not in production on the Government's account as yet, but it is a very uniform material.

Mr. GWINN. I do not know that specifically.

Senator MALONE. That is what the testimony shows.

Mr. GWINN. I am not familiar with it.

Senator MALONE. What you are saying now is you are depending upon the word of this supplier that you will have this material?

Mr. GWINN. Well, we have been using it quite a bit, sir, and are developing it.

Mr. McNamara said the material has varied considerably. We think we are narrowing those gaps all the time with the more knowledge the vendor is getting and ore forging people in handling and fabricating it.

Senator MALONE. How much of this material would you need?

Mr. GWINN. Specifically starting the first quarter of 1954 we start with 30 tons, we go up to the fourth quarter, 142 tons, first quarter of 1955, 300 tons, second quarter 390 tons and in the year 1957, 3,700 tons.

If the material becomes more readily available, we can go upward of probably 5,800 tons.

Senator MALONE. You will be using about all of this supplier's material?

Mr. GWINN. Yes.

Senator MALONE. In your one company you will be using about all that is supplied from this supplier?

Mr. GWINN. That is right.

Senator MALONE. That will be a good many times what they are now making?

Mr. GWINN. We do not intend to limit ourselves to this one company. We are working with all the companies. It so happens that we have a head start with the Titanium Metals Corp.

Senator MALONE. Let me ask you now: What would you be doing in the use of this material if it were available to you in any amount and you knew you could have it, say, next year, the years 1954, 1955, and 1956 or say 1955 and 1956.

Mr. GWINN. Probably starting 18 months to 2 years from now we probably could accelerate the use of this material and employ more of it in our engines than is presently contemplated.

AVAILABILITY THE QUESTION

Senator MALONE. Give us an estimate if you care to as to what you might use if you knew it were available in the proper quality.

Mr. GWINN. Using it as we have now forecast it and things, take the third and fourth quarter of 1955. It is presently planned to use 615 and 921 tons in each of those quarters. We think we could use an additional 405 tons in the third quarter and maybe another 600 tons or maybe two-thirds more if the material is available.

Engineeringwise we think it is practical. The question is going to be the availability of the material.

Senator MALONE. Do I understand that you have followed these designs because you followed the availability of the material as far as amounts are concerned? But I am asking you the question——

Mr. GWINN. I am speaking of production. I do not think developmentwise or experimentally there has been any holdup. We have had quite a bit of material experimentally and we are using it all the time in development.

Senator MALONE. You feel you will get all the material you need?

Mr. GWINN. No, sir.

Senator MALONE. I am asking you the question, what do you need?

Mr. GWINN. I am trying to point out that.

Mr. MCNAMARA. We will get it through the second quarter of 1955.

Mr. GWINN. I was projecting beyond the second quarter of 1955.

Senator MALONE. What could you use beyond that if you had it?

Mr. GWINN. A thousand tons the third quarter and 1,500 tons the fourth quarter.

Senator MALONE. What year?

Mr. GWINN. 1955, and in the year 1956 is 5,900 tons.

Senator MALONE. What is that?

Mr. GWINN. 5,900 tons.

Senator MALONE. About 6,000 tons.

Mr. GWINN. That is right. That is as close as we have it projected here. 6,000 is close enough.

Senator MALONE. From there on?

Mr. GWINN. It can build up beyond that. We have not projected the requirements beyond that. With further developments, if we can learn the art of welding the material we can apply more of it in the engines.

Senator MALONE. As far as you are concerned you are satisfied with the amount of production, you are being supplied.

Mr. GWINN. Well, I would not say we are satisfied. We have our fingers crossed whether we are going to get it because allocations very definitely come into it. Whether our engine will have No. 1 priority for the available titanium at the time we do not know.

Senator MALONE. How many of you are in this production of engines?

Mr. GWINN. There are five major companies.

Senator MALONE. There would not be that much titanium under present production for all five would there?

Mr. GWINN. That is right.

Senator MALONE. You are a rather favored company?

Mr. GWINN. I do not know, sir.

Senator MALONE. You have been assured you will get this amount of titanium for 1954 and 1955?

Mr. GWINN. Provided we get the allocations.

Senator MALONE. Provided you have your present allocations?

Mr. GWINN. That is right.

Senator MALONE. Which is practically all that is in sight?

Mr. GWINN. That is all apparently from this one source; yes.

Senator MALONE. There is no other source except the one that is not in production as yet?

Mr. GWINN. That is right.

Senator MALONE. Except the du Pont Corp. that is now producing 2½ tons and hopes to reach 10 tons sometime next year.

Mr. GWINN. There have been several meetings at Wright Field we have attended as one of the engine suppliers where the joint requirements have been put together. I think there was one last summer. Our needs and the other needs were discussed.

Senator MALONE. What type of engines do you manufacture?

Mr. GWINN. Axial-flow jet engines.

Senator MALONE. We are glad to have you here. If you are satisfied with the production we are glad to have——

Mr. GWINN. I do not want to leave that impression. We are definitely concerned that the availability of material will limit its use.

Senator MALONE. Is it limiting your design?

Mr. GWINN. Not design; no, sir.

Senator MALONE. How would it limit it?

Mr. GWINN. Availability of the material in quantity.

Senator MALONE. It does not seem to me like you are going to require very much, you will probably get it with first priority?

Mr. GWINN. It represents quite a few engines using it in the compressor section.

Mr. MCNAMARA. I wonder if it might clarify the matter a little bit at least to tell you at this stage of the game our engineers have only been able to approve 1 type of material from the 1 manufacturer and that is why Mr. Gwinn, why we would like to say we feel assured through the second quarter of 1955 that again has to be qualified because we have only 1 material at the moment that is available for our use.

Senator MALONE. What do you mean by one material?

Mr. MCNAMARA. TMC's technically called in the case we know of titanium 150.

Senator MALONE. The Titanium Corp. does not prepare the alloy; do they; they only make the sponge?

Mr. GWINN. They prepare the alloys.

Mr. MCNAMARA. They deliver the material to our forging vendor.

Mr. GWINN. Alloy is worked out jointly with the material supplier.

Senator MALONE. I understood that the material went to the steel company that is part-owner of the Titanium Corp. and that they took care of the melting and rolling.

Mr. MCNAMARA. Our deal is with Titanium Metals and of course the combine of National Lead and Allegheny Ludlum at the actual points of fabrication that very possibly is so.

Senator MALONE. They have no facilities where they are out there?

Mr. MCNAMARA. No.

Mr. GWINN. I imagine that is why the joint effort on the thing, using facilities. They furnish our forging manufacturer with the alloy.

Senator MALONE. The forgings, if I remember the information that you considered classified it does not coincide with your information very close.

Mr. GWINN. That is speaking about the finished pieces and finished weights per engine for one engine. Multiply that by quite a quantity and it goes up.

Senator MALONE. Give me that again.

Mr. GWINN. Our requirements, sir.

Senator MALONE. For 1 engine that you are speaking of 1 engine.

Mr. GWINN. Mr. Harvey mentioned 250 pounds weight saving in our J–57 engine. That is the first step of incorporating titanium in the J–57 engine. We think we can go quite a way behind that and effect further substantial savings, that is the first bite where we think we have a fighting chance to get the materials.

In the raw shapes that will add up to quite a bit more weight.

Senator MALONE. What I was trying to separate in your material, knowing that you have to conform with what you expect to get in your design, but what you could do if you did not have to look at that particular part of it and that the material would automatically be available when you needed it?

Mr. GWINN. We can make substantial further increases.

Senator MALONE. If you care to——

Mr. GWINN. I would rather not. I think the 250 pounds is a figure that is classified.

Senator MALONE. I did not want any classified information but I thought you could stay away from individual weights and give us some idea of the overall maybe.

Mr. GWINN. That is where I tried in 1955.

Senator MALONE. It did not sound like many engines.

Mr. GWINN. In the third quarter showing requirements for just one use of the titanium material, 615 tons. Now if we think we can get the material we can add another 450 tons usage factor in the same period, the third quarter.

Senator MALONE. What year?

Mr. GWINN. 1955. In the fourth quarter we can go from 921 up another 600 to a total of 1,521. Through the year 1956 we presently contemplate 3,700 tons. We probably could use maybe 2,000 or 2,400 additional tons of material.

That is going beyond what we have just discussed.

Engineering is well along in the development of those additional parts for the use of titanium.

They are running engines with the all-out titanium configuration.

Senator MALONE. If you have understood my question and this is your answer——

Mr. GWINN. And we hesitate to try to predicate all our production off in the future when there is a big question whether we will get the material.

Senator MALONE. I am trying to separate you—you know your engines, that is the reason we asked you to come, and we know it is a good engine from its reputation. So I do not want you to tell me anything about the secrets of preparation of this engine.

But if you could say something about forgetting the availability of this material, you should know by now, I expect what your engineers could do if you turned them loose.

Mr. GWINN. That is right.

Senator MALONE. Well, just forget the supply of the material and assume it be available in 1954 on.

Mr. GWINN. If the decision was made today that there was an unlimited supply, it would take 18 months or 2 years to prepare for it. That gets us up to where we would have requirements of a thousand tons; third quarter, 55; fourth quarter, 1,500 tons; the year 1956 would be 6,0 .0 tons and 6,000 tons in 1957, about two-thirds of what we presently forecast with our suppliers.

Senator MALONE. Forget these intervening years and supposing you had time and jump up to 1958, where would you be if you now knew you had——

Mr. GWINN. That is difficult to say not knowing what our overall schedules will be in other things. I do not think we will use less than this. I think we will definitely use more.

Senator MALONE. You are 1 out of 5 companies?

Mr. GWINN. Yes. We would not use less. That is only ourselves. That does not include our licensee. Ford are building the same engine.

Senator MALONE. Who?

Mr. GWINN. Ford Motor Co. plant in Chicago.

Senator MALONE. The committee does not know about your licenses and we are trying to ask you a question that will give us the overall use of the material and we are assuming you understand that.

Mr. GWINN. They have a parallel requirement right at the moment that is not as great as this, maybe half.

Senator MALONE. Did they make as many engines as you do?

Mr. GWINN. No. Because their present schedule—I would say it is approximately half. That is subject to change.

Senator MALONE. When you say you need 6,000 tons they would need 3,000 tons?

Mr. GWINN. Yes.

Senator MALONE. And then you are getting close to 10,000 tons?

Mr. GWINN. Yes.

Senator MALONE. Do you have any other licenses?

Mr. GWINN. No, that would be the only one.

Senator MALONE. There are no other licenses?

Mr. GWINN. No others.

A BIG FUTURE

Senator MALONE. That is quite a little progress we made in that last question. If you have another information that you think would be helpful to the committee in determining the availability of this material after you get home, we would be very happy to hear from you.

Mr. GWINN. Thank you, sir. We certainly want to support it 100 percent. We believe in this material, that it has a tremendous future.

Senator MALONE. Do you consider it a "must," as some have testified?

Mr. GWINN. I think it is very much of a must.

Senator MALONE. You are in the engine business, and one of the best known, and perhaps one of the best. What do you think would

happen if we did not have the material we needed to manufacture our engines and our frames out of this material and our potential enemy had it? What would be the comparison then in the finished product?

Mr. GWINN. There is no question we would suffer performancewise either in the ability to put the weight saving into longer range or more bomb load. It would be pretty rought. As you have so ably said before, there is no such thing as a second-best Air Force.

Senator MALONE. Well, now if these other companies are producing alongside of you as a matter of quantity, and there are 4 others, you would all be using about 50,000 tons, would you not; forty to fifty thousand tons?

Mr. GWINN. I cannot speak for the others. I think we are all in varying degrees of development.

Senator MALONE. I said if they were comparable.

Mr. GWINN. That is right.

Senator MALONE. That would be about right, counting your licensee.

Mr. GWINN. Yes, sir.

Senator MALONE. Then you do not think this one supplier is going to make up for all that, do you?

Mr. GWINN. No, sir. Something has to be done.

Senator MALONE. It would not even make up for your licensee, would it?

Mr. GWINN. No, sir.

Senator MALONE. I entirely misunderstood you in the beginning. I thought you were entirely satisfied.

Mr. GWINN. No.

Mr. MCNAMARA. We do not want to convey that impression. Beyond the second quarter of next year we are definitely unsatisfied.

Mr. GWINN. I was trying to convey the impression we have from our supplier provided these allocations, we have received a priority on the material.

Senator MALONE. Right now the material is allocated by the National Defense Organization, the Air Corps.

Mr. GWINN. Wright Field.

Senator MALONE. General, I am sorry I did not see you come in or I would have had you in this conversation before.

General METZGER. The material, Senator Malone, is allocated presently within the Air Force and Bureau of Aeronautics by my division, by the Aircraft Production Resources Agency with which you are familiar as an additional operation.

Senator MALONE. I am satisfied there would be a fair allocation but up until this year there has been no record of any Government organization that has been satisfied until they could make any material scarce enough so it had to be allocated.

Then, of course, when they start allocating it gets scarcer.

Mr. GWINN. That is pretty rough then.

Senator MALONE. What the committee, at least speaking for one member of the committee, is interested in is to see if there is anything we can do to help you and your coproducers of engines to assist the manufacturers of warcraft; also civilian use by encouraging the increased production so that they do not have to allocate, whether it meets approval of the Government divisions or not.

Mr. GWINN. It would be wonderful. That would be extremely helpful. We could really set our production targets high and shoot for them.

Senator MALONE. I think we can find out what makes some of these Government agencies tick. That is probably what we will have to do because there has been such an epidemic for 10 or 15 years of controlling every material.

Mr. GWINN. Titanium as we understand it, the basic material, there is quite a bit of it available in North America and from a strategic material standpoint it is very attractive.

Senator MALONE. You think that is an advantage.

Mr. GWINN. We think it is a distinct advantage, sir, in the case of an emergency.

Senator MALONE. Have you been through recently one of those allocation periods when it was almost impossible to get the raw material across an ocean from which this product was made?

Mr. GWINN. Oh, yes; we have been through a lot of them, aluminum at the start of the last war. They were sinking ships in the gulf right and left.

Senator MALONE. I have a list here, practically all of these includes material including titanium and the Bureau of Mines says that with the parade of their experienced engineers, many of them spending their lives in an area of materials, they come out with industrial diamonds.

If we had a sensible program we might not get enough industrial diamonds in the Western Hemisphere. There are substitutions, replacements and a sensible program could be made available for what we need in war. Therefore it would take us out from under the possibilities of blackmail in a trade to get the materials in peacetime and where, according to testimony of General Metzger and others that I feel are very competent in this field, probably made unavailable in the next war. So you agree with the general that it would really be very helpful if we had materials such as titanium or all of the raw material could be obtained in this country or adjacent areas?

Mr. GWINN. Absolutely; there is no question about that.

Senator MALONE. You agree with the general, you probably heard his statement today.

Mr. GWINN. Only partially, sir. I am sorry we were detained in getting here.

Senator MALONE. You agree that at the moment our manufacture of this important product is pitifully inadequate?

Mr. GWINN. It certainly seems to be, sir.

Senator MALONE. Well, if you have any further information you think would be helpful to the committee we would appreciate it if you send us a brief and it will be made part of your testimony. Does your associate have any information to offer?

Mr. MCNAMARA. No, sir.

Senator MALONE. Thank you very much.

We have Dr. Jenness here, of Kennecott Copper Corp. Dr. Jenness, will you come forward, please?

STATEMENT OF L. G. JENNESS, KENNECOTT COPPER CORP.

Mr. JENNESS. Yes, sir.

Senator MALONE. Dr. Jenness, we are very glad to have you here.

The name of Kennecott Copper Corp. is very familiar to the junior Senator from Nevada, one of the largest copper pits in the world is operated by this company and it is well known throughout our State as one of the greatest and most efficient organizations in the State.

Mr. JENNESS. Thank you, sir.

Senator MALONE. Naturally they have their little difficulties here and there but they are run by competent men. Therefore, we feel that any business that Kennecott becomes interested in there would be a definite reason and that they would very soon know what they were doing.

You have listened to testimony, you know the objectives of the committee, to determine the availability of these materials of which titanium happens to be one of the most important.

Would you make any statement that you care to make that you think would be helpful to the committee? Identify yourself for the purposes of the record, please.

Mr. JENNESS. Quebec Iron and Titanium Corp. is owned jointly by Kennecott and New Jersey Zinc. They have an ore body which has proved 125 million tons of ore and probably 2 or 3 times more than that would be expected. They have also entered into a smelting operation to convert that ore to a slag containing 70 to 72 percent Ti 02 which would be comparable to some 40 percent of titanium on a metal basis.

The operation was first worked with one furnace for experimental purposes. At the end of October or November of last year it was placed on a 3-furnace basis and in March or April of this year 2 remaining furnaces or a total of 5 furnaces were placed in operation and are in operation.

We have had an improvement as time has gone on. You will have to appreciate that we only placed the fifth furnace in operation as of April. The annual rate of production as of April was 135,000 tons. The annual production rate at October was 177,000 tons.

So kindly bear in mind that this is a pioneer operation which we are in, it has improved at a considerable rate over a short period of months. We do not wish to convey any impression that there are no problems in the titanium industry.

Senator MALONE. If there were no problems everyone would be in it.

Mr. JENNESS. We have plenty of them and we are not saying this is an easy project but we are trying to picture to you the progress which we have made in that field.

The annual rate of 177,000 would be about 70,000 tons of titanium metal.

I am sure we will make every effort to try to supply the titanium industry to the best of our ability and the progress which I have shown indicates that it will continue.

Senator MALONE. You produce this as your main product?

Mr. JENNESS. Both slag and iron are produced by the smelting operation.

Senator MALONE. You have a definite sale of course for all the pig iron you can produce.

Mr. JENNESS. Up to the present time there is no problem there.

Senator MALONE. Do you have a ready market for all of the titanium slag that you can produce?

Mr. JENNESS. We have many times rejected orders which we could not fill.

Senator MALONE. You have heard the testimony today?

Mr. JENNESS. I have.

Senator MALONE. Supposing the use of titanium over the foreseeable future, 1954, 1955, 1956, 1957 and on to 1960, the estimates that have been made by Mr. Hurley of one of the very prominent engine manufacturing companies and General Metzger in charge of Wright Field, do I understand you to believe that your production of this material could keep pace if you knew you had the market?

Mr. JENNESS. I could not guarantee that, no, but I think that there is a very good expectancy that it can keep pace.

Senator MALONE. Is this ilmenite-bearing ore, a rather plentiful occurrence depending of course on grade in other areas?

Mr. JENNESS. I do not know of any material of this grade. I know some of still lower grades which are available.

Senator MALONE. What is the grade? Would you tell us the grade of the ore now, the pig iron and also the titanium content, the slag?

Mr. JENNESS. The ore contains 35 percent of titanium oxide which would be about 20 percent titanium metal.

Senator MALONE. How much pig iron?

Mr. JENNESS. The iron is considerably higher. I do not recall the figure at the moment.

Senator MALONE. Just approximately?

Mr. JENNESS. It is a mixture of two-thirds of ilmenite and one-third hematite. We have one-third hematite, which is additional iron. I may have the actual percentage available here.

Senator MALONE. If you have the figures available on the amount of pig iron per ton it might be helpful because it is an overall production.

Mr. JENNESS. Here is a reprint of a publication made in 1952 and the iron is given as 40.3 percent.

Senator MALONE. That would be actual iron content of the ore?

Mr. JENNESS. That is right.

Senator MALONE. Eight hundred pounds of the pig iron would come out of a short ton of ore.

Mr. JENNESS. Largely so. There is some iron left in the slag.

RESERVE FIGURES

Senator MALONE. I might ask this question in another way: I do not want you to boost other deposits in competition with your own, but would you say that the ilemite product or the ore in the United States and Canada would be equal to the occasion regardless of any need that you have heard mentioned here today?

Mr. JENNESS. I am not sure that I get the question.

Senator MALONE. In other words, not only including your own deposit and operation but would you say that the deposits, the occurrences, of this ilmenite ore in the United States and Canada from what you know about the situation would be adequate for any potential use of titanium that you have heard mentioned yesterday and today here?

Mr. JENNESS. I was not here yesterday.

Senator MALONE. You heard the testimony today that it might result in four or five or six hundred thousand tons of titanium metal per year?

Mr. JENNESS. Five hundred million or a hundred million tons of titanium, which should go quite a way.

Senator MALONE. Your reserves there are 100 million tons?

Mr. JENNESS. They are proved at 125 million tons of ore. That is by drilling.

Senator MALONE. I understand that you believe there are several times that amount.

Mr. JENNESS. Probably three times that amount.

Senator MALONE. That would make a good deal of titanium.

Mr. JENNESS. Yes.

Senator MALONE. Thirty million tons, 25 percent.

Mr. JENNESS. The proved part, 25 percent; yes.

Senator MALONE. You do not believe, and I am still not trying to get you to promote someone else's deposit but you do not believe you have the only deposit of ilmenite in Canada and the United States; do you?

Mr. JENNESS. No, there are others. I do not know of any of the magnitude of this.

Senator MALONE. But there is no scarcity of the ore? You think we could become self-sufficient in the United States and Canada without any real difficulty in the production of any reasonable amount of titanium that you have heard estimated so far in future years?

Mr. JENNESS. Over some period of time; yes.

Senator MALONE. The testimony has been offered to this committee that it is about the fourth or fifth most plentiful metal, mineral, in the earth's surface. It is a question, of course, like other ores of concentration profitable to mine. If that is true there is no scarcity of that material in the United States and Canada for any estimates of production of titanium metal that you have heard?

Mr. JENNESS. Well, in regard to the ability to produce titanium it is certainly going to last for a long time.

Senator MALONE. Do you think there is any problem that would keep the production of titanium from becoming adequate for whatever its use once several of the—one of the known problems are whipped that you know are being worked on at the present time? Do you think there is any limit to the production to meet the needs of the industry?

Mr. JENNESS. If you are referring to any extended period of time, why then obviously they are bound to be exhausted some day.

Senator MALONE. If you are going to join the Ickes school that you want to save your deposits and get it from India or Australia, I was just trying to determine which school you belonged to.

Mr. JENNESS. I think we belong to the school that wants to use our deposits.

Senator MALONE. Do you think there is any scarcity of this material in the foreseeable future from what you know about the ilemite and iron deposits in the United States and Canada?

Mr. JENNESS. No.

Senator MALONE. You do not think so?

Mr. JENNESS. No.

Senator MALONE. Neither does the chairman. That is going a good ways for an engineer and I take it you are one.

Do you have any further information for the committee?

Mr. JENNESS. Only to the extent that our corporation, Kennecott Copper Corp., is working on production of titanium metals and of course through our subsidiary, Chase Brass & Copper, on the fabricating.

Senator MALONE. It is the Chase Brass & Copper Co. working on the production of titanium metal.

Mr. JENNESS. They have done some work naturally in connection with Kennecott, they are a wholly owned subsidiary.

Senator MALONE. What part of the Kennecott Corp. is working on the production of titanium metal?

Mr. JENNESS. The corporation has work in process at various institutions as well as of our own facilities.

Senator MALONE. What part of the Kennecott Co. is working on the production of titanium metal?

Mr. JENNESS. The corporation itself is working and also it has work in process at various institutions as well as our own facilities.

Senator MALONE. What would you consider is the stage of these operations?

Are they about ready to build a plant or go into production or what would you say is the stage of your operations?

Mr. JENNESS. One of our processes is ready to go into a higher stage of development than the 200-pound per day pilot plant which we have in operation at the present time.

Senator MALONE. That is operation at present?

Mr. JENNESS. This particular process passed through the stage of the order of a pound per day. We then carried it up through a 200-pound per day unit, and we are now considering further expansion.

Senator MALONE. Are you now considering a real production plant?

Mr. JENNESS. Either a real production plant or what might be called a prototype of that.

Senator MALONE. One definition of prototype we had today is a large pilot plant. Is that what you would call it? It is new to the chairman.

Mr. JENNESS. It would be called something on the order of 1 or 2 tons a day.

Senator MALONE. They still call those pilot plants in the Bureau of Mines. What is your objective in the operation of the pilot plant? When would you be ready in your estimation to go into it, to build a plant for real production?

Mr. JENNESS. We naturally tend to be in the metal business, so our objective is to make titanium metal and we are considering whether we will erect a prototype or perhaps advance somewhat to a higher stage of the order of 10 tons.

Senator MALONE. You have not decided about that yet?

Mr. JENNESS. No; those decisions rest with our board of directors and our president.

Senator MALONE. Of course, the committee would be interested in whatever plans you might have and the stage of your plan to go into real production and now you are just undecided as to what type of plant you will build. If you decide to build the large pilot plant or

the prototype plant, how long do you suppose it would be before you are ready to go into the construction of a 10- or 20-ton plant, or whatever size you decide to build?

Mr. JENNESS. I would think that there might be possibilities of eliminating a prototype because we have under operation for further development the present pilot plant, and I would estimate something of the order of 1956 if we took that approach.

Senator MALONE. That you would start to build a plant or would be in production.

Mr. JENNESS. Would be in production.

Senator MALONE. Whatever plant you decide to build you will start right away?

Mr. JENNESS. Yes, sir.

Senator MALONE. On your own account?

Mr. JENNESS. That is not certain, what we can do with the Government, for the national defense, for there is nothing definite worked out at the present time. We have been invited before the technical committee headed up by Dr. Frary, who has previously been referred to here, and that is about the stage that we have gone.

Senator MALONE. Is that preliminary to going before the General Services Administration?

Mr. JENNESS. We were invited to attend that committee. Obviously we were in the midst of considering the stepup of this process, and we had accepted the invitation to go and describe the type of process we were involved in.

Senator MALONE. You have done that.

Mr. JENNESS. We have done that.

Senator MALONE. How long ago?

Mr. JENNESS. Only a few weeks ago.

Senator MALONE. What would be the next move providing they thought you had a feasible process and reported favorably upon it?

Mr. JENNESS. It is my impression that a further committee investigates the technical feasibility of the process.

Senator MALONE. How many committees are lined up ahead of you now before you reach someone who can talk about business?

Mr. JENNESS. There are two at least.

Senator MALONE. What is the other one?

Mr. JENNESS. GSA.

Senator MALONE. GSA as we finally understood here can actually give you a contract if they want to do so and have considerable latitude in writing the contract. What is the type of contract if that is a permissible question—we do not want you to disclose any of your plans that you are not going to disclose anyway, we are only interested in the progress or imminence of this production.

Mr. JENNESS. Our plans were first to see what could be done with the Government. There are no plans with our own company of whether we would care to ask for a loan.

I would not believe that they are interested in a loan. I am speaking personally.

Senator MALONE. You think they would be or not be.

Mr. JENNESS. I think they would quite possibly carry the funds themselves. It would depend on the degree of what size we went to. Naturally that would limit to some extent probably the size.

Senator MALONE. What size would you have in mind?

Mr. JENNESS. As I said, between 1 and 10 tons.

Senator MALONE. One ton would naturally be a sort of a pilot plant?

Mr. JENNESS. Yes.

Senator MALONE. Ten tons, we would consider you in production, no doubt.

Mr. JENNESS. That is right.

Senator MALONE. If you went into the 10-ton plant then without disclosing any of your plans, if you care to answer, would you be asking for a loan under the conditions that the du Pont Co. and Titanium Corp. have secured loans, or would you make some kind of proposition—you heard the testimony of Union Carbide today that they would put up the money if they got a contract at a sufficient price to cover the amortization.

Mr. JENNESS. We are trying to find out what could be done so that we can take some action in our company. Bear in mind that the board of directors would have to approve whatever plans there are.

Senator MALONE. You are the engineer in charge, is that right?

Mr. JENNESS. That is right.

Senator MALONE. Your remedy, if I understand your testimony, would be really that you go into production with maybe a 10-ton plant?

Mr. JENNESS. I am sorry, sir.

Senator MALONE. If I can add up your testimony it is that you would favor skipping the 1-ton and going to a 10-ton plant at least?

Mr. JENNESS. Yes.

Senator MALONE. Then go to the action of your board of directors; after they have taken action then you would know what you would request from the GSA but you would be ready to make your request and as far as you know you are ready to go ahead?

Mr. JENNESS. We are ready to go ahead.

FOR HIGH PURITY

Senator MALONE. What is your process?

Mr. JENNESS. It is a thermal-dissociation process and we are aiming for high-purity metal, something of the order of 120 Brinele or lower.

Senator MALONE. Now you heard talk of batch processes and continuous processes and they have sort of been modified one into the other, but what would you call your process?

Mr. JENNESS. I heard Union Carbide's testimony. I think I would call this a continuous process with the intermittent removal of titanium.

As Dr. Kinzel stated many times it is a continuous process with one process a batch or semibatch operation.

Senator MALONE. What do you think the future of this metal might be?

Mr. JENNESS. I think the future of the metal is very great. We also appreciate that it is a very difficult problem. I mean relative to many things which have been processed. Therefore anything that I am saying I want it understood that we appreciate these problems, both in raw materials and in metal.

Senator MALONE. What has been your observation and experience in the engineering field, that when there is an incentive or profit to whip any certain problem in a metal that the scientists and engineers generally come through in pretty good shape?

Mr. JENNESS. My experience is that if someone feels that an objective——

Senator MALONE. Which means a reasonable profit overall.

Mr. JENNESS. That is right—then there is great effort to achieve that objective.

Senator MALONE. And they generally reach the objective.

Mr. JENNESS. That is right. They come up against what looked to be insurmountable problems but they continue on.

Senator MALONE. I take it from your testimony that you are not afraid of these problems, that it is a question of having the wherewithal and incentive to meet them and you are not afraid of the market for the material once it is available.

Mr. JENNESS. We are not; in making our choice we strove toward a purer metal.

Senator MALONE. What would you say about the cost?

You know what the cost is now, at least the contract price of $5 per sponge, about $15 for the finished material, as high as $20 for the shapes.

What would you say that the cost, about the cost of this material over a period of years, the foreseeable future, if the demand is what you would estimate it to be?

Mr. JENNESS. I think as the result of development the costs are going to be reduced, and I believe that we can see figures below what have been quoted as obtainable by the Kroll process.

Senator MALONE. In other words, you would look forward over the foreseeable future to a substantial reduction in the cost of production?

Mr. JENNESS. Yes, sir.

Senator MALONE. Thank you very much and if you have any further information you would like to furnish the committee at any time, we would be very glad to receive it as part of your statement.

Mr. JENNESS. Thank you.

Senator MALONE. Thank you.

Mr. George of the New Jersey Zinc Co.

STATEMENT OF C. H. GEORGE, THE NEW JERSEY ZINC CO.

Senator MALONE. Mr. George, you are familiar with the objectives of the committee and any statement that you would have to make you may read or an oral statement or submit anything for the record that you think might be helpful.

Mr. GEORGE. Thank you. My name is C. H. George, vice president of the New Jersey Zinc Co.

You have asked us, Mr. Chairman, to inform your committee as to the position of the New Jersey Zinc Co. in the field of titanium.

We are glad to do that.

There are two phases of this development in which the New Jersey Zinc Co. is involved.

(1) The production of titanium-rich slag suitable for use as a raw material for titanium metal;

(2) Research by its subsidiary, the New Jersey Zinc Co. of Pennsylvania, in an effort to find and develop an efficient and economical method of producing ductile titanium metal.

Slag is now being produced by the Quebec Iron & Titanium Corp., which is owned jointly by Kennecott Copper Corp. (two-thirds) and the New Jersey Zinc Co. (one-third).

Senator MALONE. Let me understand your position a little clearer. Are you associated with the operation Dr. Jenness just mentioned?

Mr. GEORGE. Kennecott Corp. and New Jersey Zinc Co. are partners in the ownership of the subsidiary Quebec Iron & Titanium Corp. which was formed to exploit these ores in Quebec.

Senator MALONE. This is the same operation described by Dr. Jenness?

Mr. GEORGE. Yes, sir. I will not go into the detail Dr. Jenness did because he is closer to that than I am. I want to indicate to the committee what the position of the company is with respect to the metal titanium.

That jointly owned subsidiary was formed to mine the large deposits of iron-titanium ore found in the Lake Allard region of eastern Quebec and to treat the ore in electric furnaces at Sorel, Quebec, to produce slag and iron. The titanium is concentrated in the slag, which normally contains 70 percent to 73 percent titanium (as dioxide). Under present conditions the slag is being utilized as a raw material in the production of titanium pigments, principally by United States pigment manufacturers. It is suitable for use also as a raw material in the production of titanium metal.

The ore deposits are very extensive; more than 125 million tons of ore have been proven by drilling, and in the opinion of our geologists the quantities of ore available in those deposits greatly exceed that amount. The extension of the facilities for the electric furnace treatment of the ore is dependent on the supply of money and electric energy.

The research activities referred to have been under way for several years. We spent 2 to 3 years in surveying and studying potential processes in order to select the most promising one under our conditions. In all, we looked at 20 or more combinations of reactions that had possibilities of yielding pure metal. Work on the method finally chosen is now in the laboratory and semipilot plant stage.

On the basis of experience to date indications are that the process is technically feasible, produces ductile titanium, and is promising from the standpoint of economical operation.

We will not know with certainty, of course, that we have a process capable of commercial development until we actually operate an integrated pilot plant. It is hoped that we may be in position to undertake the design and operation of a small pilot plant sometime in 1954.

That is our position, sir.

Senator MALONE. Would that be the 1-ton pilot plant or something similar?

Mr. GEORGE. The pilot plant would not be that large, about 200 pounds a day.

Senator MALONE. You feel——

Mr. GEORGE. We feel that is all we need under the conditions of our process which would lead to a multiplicity of units.

Senator MALONE. How long would you need to operate the pilot plant before you would be sure and before you would be ready to——

Mr. GEORGE. I asked our technical people that but as you know this is a difficult thing and it is not easy to predict how many difficulties may arise and how long it will take to overcome them but they think we would need a year at least.

Senator MALONE. It would be 1955 before you are ready to proceed.

Mr. GEORGE. Yes. With a plant of about 10 tons a day.

Senator MALONE. You probably have not looked that far ahead but if you have do you know what sort of a plan of financing you would have?

Mr. GEORGE. We have not approached that problem yet. So far we have put up our own money.

Senator MALONE. In your sizeup of the titanium situation you have heard in the testimony today, what is your opinion of the future of this metal as far as quantity and practicability of use is concerned?

Mr. GEORGE. Of course, Mr. Chairman, we have been persuaded by all of the information that has come on to us from many quarters over the past few years that it has a promising future or we would not have spent the large sums of money we have on research.

Senator MALONE. I am sure of that, but I thought you would make it more definite.

Mr. GEORGE. We are assured it has a large future.

Senator MALONE. You feel that there are any problems, and you do have problems, that will not be conquered within a very reasonable time if the demand develops as you think it will?

Mr. GEORGE. Well, we think that the problems that we still see in our process can be overcome and are solvable.

Senator MALONE. What do you call your process?

Mr. GEORGE. Electrolytic process.

Senator MALONE. Electrolytic process?

Mr. GEORGE. Yes.

Senator MALONE. You have heard the talk about continuous and batch processes.

How would you classify that?

Mr. GEORGE. Continuous.

Senator MALONE. Thank you very much; and, Mr. George, if you have any further information you think will be helpful to the committee, will you communicate with us?

Mr. GEORGE. Yes, sir; I will.

Senator MALONE. Thank you very much.

Mr. Mochel, of the Westinghouse Electric Corp. Will you come forward and identify yourself?

STATEMENT OF NORMAN L. MOCHEL, WESTINGHOUSE ELECTRIC CORP.

My name is Norman L. Mochel. I am manager of metallurgical engineering for the steam division and consulting engineer on materials problems for the balance of the company.

I have with me Mr. Goldberg, who is the chief metallurgist of the aviation gas-turbine division.

Senator, we have brought along a prepared statement consisting of some 20 pages. I do not intend to read those 20 pages. I am fearful

that at this time of the day and in your hearings that much contained in it would be possibly looked upon as elementary and a great deal of it would be repetition, but I would like to emphasize 1 or 2 points and leave copies of this statement with you.

Senator MALONE. You can make your oral statement and then submit the copy for inclusion in the record as part of your testimony.

Mr. MOCHEL. Thank you.

It was in June of 1949 after preliminary work of laboratory samples the Westinghouse Corp. considered that the titanium problem was one that merited their attention, and in their own forging shops they forged some two disks for the compressors of jet engines, one of which was cut up for laboratory tests, and the second one was machined to finished state and actually operated on a hot-test stand.

PROBLEMS INVOLVED

From these tests and other laboratory tests that were under way the Westinghouse management was convinced titanium had a definite place in their jet-engine work. Considerable testing done at that time resolved itself into three problems, which were:

First, the matter of being able to secure a high-quality sponge;

Second, the producing of titanium and titanium alloys which were uniform in chemical analysis, which met minimum design requirements, which were metallurgically stable, and which were amenable to manufacturing practices, and

Third, we wanted to be assured of an adequate supply.

Now, despite these three problems, which looked to us to be very great, we did go ahead and gained further experience by doing disk forgings on ingots and other parts to try them out further.

As a result of this additional experience in June of 1950, a year after we had made the first disk forgings, we felt it was time to put titanium into engine parts and we did select the best known alloy at the time and did buy a great number of forgings.

Financially what they are worth today I am not even going to mention. We do have on hand a large number of disk forgings which will never be used, but which were considered the best that could be produced at the time.

Senator MALONE. They are part of the development process; is that right?

Mr. MOCHEL. That is right. We therefore decided to slow down our operations and to go to work on some of the problems that seemed to confront us and we took a number of steps.

We actually produced engine parts such as compressor disks, compressor blades, bolts for the compressors, and other parts, and some of these parts have been incorporated in our engines and have gone through 150 test hours of operation.

The results of these tests were so satisfactory that our future planning so far as materials are concerned includes titanium as an engineering determination. That did not at all mean we were satisfied with the grade of material being produced in the present state of the titanium art. Very definitely we did not.

We are urgently recommending to you that full consideration be given to producing a higher quality sponge than that which is on the market today.

Senator MALONE. You know the specification. What should be the specifications in your opinion with your experience now?

Mr. MOCHEL. We have included an appendix here, appendix A, which deals with the manufacture of sponge and the manufacture of alloys and which goes into that at considerable length; and if I may, I would like to leave that with you, Senator.

Senator MALONE. Just submit your statement for the record, and it will be included when you finish.

Mr. MOCHEL. We feel that low Brinell hardness of the sponge is quite essential. That is, Brinell hardness of not over 140 to 150. We were very gratified to hear the remarks made by my predecessor that possibly 120 could be met.

Senator MALONE. That would be even better?

Mr. MOCHEL. That would be even better. We are including this statement to which some might take exception. Our industry would rather see titanium produced at a lower rate, but with higher quality than at the high production rates now being forecast and with the existing quality level.

Now we have enumerated the objections to titanium from an engineering standpoint, we have also listed those very desirable characteristics. I think all of them have been repeated either yesterday or today and I am not going over that further here.

We have dealt with the matters of expense in his statement to some degree because we do not feel you can lightly pass over the matter of expense. It is definitely a factor. End use must recognize the greater costs involved in this particular work, and we believe that we must give consideration to it.

Senator MALONE. You are speaking of civilian production; is that right?

Mr. MOCHEL. Speaking of civilian production, but I must also say that costs are not completely neglected even in military considerations.

Senator MALONE. No, but you would not be the one to make the decision.

Mr. MOCHEL. We would not be the one to make the decision. It would be the end user who would have to make that decision.

Senator MALONE. The military organization; would it not be?

Mr. MOCHEL. That is true.

Senator MALONE. National Defense would make that decision.

COST WILL DETERMINE USE

Mr. MOCHEL. In Westinghouse gas turbines we are specifying titanium in such places as compressor disks, compressor blades, compressor through-bolts, and some other miscellaneous parts. The extent it will be used will depend upon how much the ultimate user is prepared to pay for it.

Titanium is an expensive material, it is costly to handle in the shops, there are attendant time delays due to increased manufacturing time which means more machine tools and increased engineering aids, which the manufacturing departments need to successfully produce components.

Technically titanium can be used in increasingly large amounts. The Westinghouse Electric Corp. estimates it will use the following amounts of titanium in the next year if the end user can justify the cost:

(*a*) Forty-one tons of bar, billet, and sheet, requiring 58 tons of sponge, per month for the first half of 1954.

(*b*) Approximately 55 tons of bar, billet, and sheet, requiring 90 tons of sponge, per month, starting July 1954, through the balance of the year.

Senator MALONE. You have this amount in sight under contract or promised?

Mr. MOCHEL. We have been allocated those amounts. We have hopes of procuring those amounts. It will be a serious matter to us should we not get those amounts in usable alloy.

Senator MALONE. But this is pointed toward a product for the Air Corps or for national defense.

Mr. MOCHEL. Bureau of Aeronautics. We have been allocated the material, and on paper we are going to get it. We have confidence that the grade we will get will be satisfactory for our purposes, and we are counting on using these amounts.

Senator MALONE. We went through an experience of that kind, it seems to me, within the memory of most of us, and the answer was it was under contract, but we didn't get it.

Mr. MOCHEL. We have been through that. We also point out in this article that approximately 28 percent of the titanium forgings currently being received are being rejected, indicating that the quality leaves much to be desired.

These high rejection rates need to be reduced if the designer is to have the confidence he should have in the parts.

The use of titanium in jet engines results in important weight reductions, depending upon the extent to which titanium substitutions are made. For example, in our important weight reduction program, the maximum use of this alloy can reduce the engine weight 90 to 100 pounds with specific savings of 8 pounds per compressor disk and 4 pounds for two stages of compressor blading. Before seriously considering the maximum possible use of titanium, Westinghouse wants to be assured of a continuing supply—250 pounds is the figure very closely related to the figures given elsewhere here.

Senator MALONE. What is the total weight of such an engine?

Mr. MOCHEL. The total weight of such an engine is between three and four thousand pounds, about 3,000 pounds the engine I am referring to here.

Senator MALONE. Would reduce it about 8 to 10 percent?

Mr. MOCHEL. That is right.

Senator MALONE. That is just a preliminary start?

Mr. MOCHEL. We think that is just a start, because the article also says that so far as future planning is concerned, we can say that engines that are still on the design boards incorporate titanium to a larger and larger degree than is presently the case.

Senator MALONE. What do you think, with the knowledge you now have, would be the maximum in such an engine in percentage?

Mr. MOCHEL. Dave, has your thinking gone far enough to estimate what that percentage would be in the engines now on the design board?

Mr. GOLDBERG. With the alloys presently available, the maximum would be about 35 percent. If some of the new alloys develop satisfactorily, it might go up.

Senator MALONE. Depends on future development?

Mr. GOLDBERG. Strictly future development.

Mr. MOCHEL. Today much of what has been said around this table has been around the aircraft industry and applications to this, and without detracting from it and what I have said has been in that field, too, there are a number of other places in which titanium could be used to very good advantage.

As a matter of fact, we feel so strongly about it at Westinghouse that we are now designing reducing and sponge melting furnaces for the industry. We feel so strongly that titanium will have wide application in other phases than just in aviation.

Senator MALONE. In civilian use?

Mr. MOCHEL. That we are actually going into the designing of ore reducing and sponge melting furnaces, since furnaces are a part of Westinghouse products.

Senator MALONE. What is the particular advantage of titanium in furnaces?

Mr. MOCHEL. We are designing furnaces for the purpose of ore reduction and melting. The Westinghouse Corp. engages in furnace business, and we feel so strongly about this that we have turned some of our best people over to thinking and designing furnaces for this particular activity.

Senator MALONE. I would say again, knowing the reputation of Westinghouse like Kennecott Copper, that when you do that, it is a good sign that the brains in your organization believe it will be a very great, that it will be of very great importance as a future metal.

Mr. MOCHEL. We have pointed out in this that in the electrical field there are several places that titanium will no doubt find a place. In the steam-turbine field and in the gas-turbine field for other purposes than aviation, we too feel titanium will eventually enter in there and when you come to the marine field of applications, surface condensers may well use condenser tubes made of this material because of the excellent resistance to salt water.

We are convinced it will be used in a great many places other than just the field of aviation.

SUGGESTS FLEXIBLE STOCKPILING

We have heard something about stockpiling today, and we want to leave just one thought with you. The Government should not stockpile sponge which cannot be converted to useful alloys. It would be a very sorry state of affairs if we were to stockpile materials that eventually could not be used. That is relying on props that fall from underneath you.

We believe any stockpiling program should be a very flexible one, that as new and better materials are developed, any of the older and less desirable materials in the stockpile should be gotten rid of so that whatever we have in the stockpile is the best that we know of at that particular moment.

Senator MALONE. Right at that point, the specifications for the titanium of the Titanium Corp., as testified to here yesterday, I believe,

was 225 Brinell hardness. It has also been testified to rather freely and frequently here that that is not available for many of the uses; so you would have in mind the Brinell hardness and possibly other matters; is that right?

Mr. MOCHEL. We question stockpiling and relying too greatly on titanium that would run that Brinell hardness.

Senator MALONE. Where do you think it should run?

Mr. MOCHEL. Present thinking is around 140 to 150.

Senator MALONE. To make it available and its workability satisfactory?

Mr. MOCHEL. That is right.

Senator MALONE. Of course, what the chairman says should not be considered as a criticism of the General Services Administration for their first conclusions, because they had to make some kind of specifications; and at that time these investigations of yours, for example, were not available. But you are talking now to the committee about future specifications?

Mr. MOCHEL. That is right.

Senator MALONE. And future contracts that might be let to the people that you saw here today, very anxious to get into production.

Mr. MOCHEL. We just look with alarm at any stockpiling of materials that you are not going to be able to use. That is just resting on something that isn't there.

Senator MALONE. Yes. Then the idea of the Government taking something that is not in demand in industry wouldn't meet with your approval?

Mr. MOCHEL. It does not meet with our approval, sir.

Senator MALONE. That is very good information for the committee.

Mr. MOCHEL. The second recommendation we make is in regard to cost, decreasing the cost. We believe that the present spread between $5 a pound for sponge and $20 for sheet reflects an abnormally high scrap rate, and we believe that if the problems which cause this high rejection can be eliminated, better sponge, better methods, better care, then we believe that there will be a reduction in price.

Senator MALONE. Those are some of the problems?

Mr. MOCHEL. That is right.

Senator MALONE. Another problem is the utilization of the scrap, is it not?

Mr. MOCHEL. It is very much of a problem.

Senator MALONE. Do you think there is any problem there that can't eventually be conquered?

Mr. MOCHEL. We believe that eventually it will be conquered. How long a problem it may be is a little bit open to question at the moment, but certainly it would appear that any method, a method must eventually be developed that will take care of our scrap.

Our third thing is Government controls. We believe that the work of the various agencies of the Government involved in titanium development and control, even though we may criticize it at times, has been invaluable to industry, and we urge that it be carried on at a higher level, and we would urge some dynamic leadership to be put into it.

Senator MALONE. You are talking about leadership in securing more metal.

Mr. MOCHEL. Securing more metal, in securing or instituting those research activities that will give us better sponge, that will take that sponge then and put it into better alloys, because we believe that it is only going to be with better sponge and better alloys that this thing is going to reach the full result that it ought to reach.

Senator MALONE. One of the habits and apparently objectives of the Government agencies over the last 10 or 15 years is to always have almost every material in a position so they must allocate it. One of the objectives of this committee is to arrive at some conclusions that would have as an ultimate objective enough material so that allocation is not necessary.

Now, of course, in case of a sudden emergency and a real war, naturally, many things might be subject to allocation for a short time; but if we could get out of the category of being dependent on foreign nations for the raw material, the many raw materials for which we are now dependent upon foreign nations, we think it would be quite an objective.

Mr. MOCHEL. Quite so.

Senator MALONE. That is the reason we encroached upon your valuable time and the testimony is very informative and valuable to this committee, because you are in the business.

This is the same Westinghouse that tried to compete with the foreign nation in the bid for a generator, was it not?

Mr. MOCHEL. Same company.

Senator MALONE. You pay about 3 or 4 times the wages and you didn't do so good.

Mr. MOCHEL. That is right.

Senator MALONE. So that is another point. We are now buying titanium from Japan.

Mr. MOCHEL. Yes.

Senator MALONE. And they are making great plans to increase their production?

Mr. MOCHEL. Yes.

Senator MALONE. I think you will encounter problems as you go along, but there is nothing sensible people can't conquer in the opinion of the chairman after hearing all this testimony.

Mr. MOCHEL. That is right.

Senator MALONE. I am glad that you agree that while there are problems, they are in the process of being solved.

Mr. MOCHEL. We think they are. May I offer a copy of this?

Senator MALONE. It will be accepted and made a part of your testimony at this point.

(The statement referred to above is as follows:)

STATEMENT OF THE WESTINGHOUSE ELECTRIC CORP. BY L. E. LYNDE, VICE PRESIDENT, AVIATION GAS TURBINE DIVISION

SUMMARY

The Westinghouse Electric Corp. has shown a continuing interest in the development and application of titanium. This is shown by the technical articles written by Westinghouse engineers and to the extent which titanium has been incorporated into our gas turbines. Since titanium is now considered one of the major engineering materials presently available, it is recommended to the committee that the following areas be explored:

1. Increase quality of sponge

The Government should not stockpile sponge which cannot be converted to useful alloys.

2. Decrease cost

The spread between the $5 per pound for sponge to $20 per pound for sheet reflects an abnormally high scrap rate. If the problems which cause this high rejection are eliminated, greater production will be immediately available at a lower end price.

3. Government controls

The work of the various agencies involved in titanium development and control has been invaluable to industry. If possible, their work should be continued at a high activity level.

4. Availability

The needs of the various gas turbine and airframe manufacturers will have to be carefully balanced to see that the titanium is allocated most judiciously. This should be done until the industry becomes more competitive.

In the period from 1948 to the present, industry has seen the development of a material which has no commercial parallel. During 1948 Du Pont produced occasional 10-pound heats of ductile titanium; today there are producers making 4,000-pound melts daily. This growth would not have been possible without the basic work of Dr. Kroll, the guidance of such Government agencies as the Aircraft Production Resources Agency and the Bureau of Mines, and the financial support of the Department of Defense.

We feel it fitting and rightly so that the committee review the titanium picture. A similar review, of where titanium fits into the Westinghouse future planning, has recently been made. The discussion which follows covers not only the early tribulations with titanium but it also presents a forecast of the immediate future requirements.

In June 1949 Westinghouse forged two 300-pound pancakes from a Du Pont commercially pure titanium analysis. One of these disks was sectioned for metallurgical analysis and the other machined to a J–40[1] compressor disk configuration. This latter disk was then subjected to a hot spin test. The data from these early tests convinced the management of Westinghouse, with the encouragement of the Bureau of Aeronautics, that substantial weight savings could be affected in gas turbine engines.

As with all new materials, the problem was not one of only making a decision to start using this metal but was one of overcoming such problems as—

(*a*) Producing a high-quality sponge;

(*b*) Producing titanium and/or titanium alloys which were uniform in chemical analysis, which met minimum design requirements, which were metallurgically stable, and which were amenable to manufacturing practices;

(*c*) Insuring an adequate supply.

Despite these seemingly insurmountable problems Westinghouse, in order to gain further experience, ordered additional compressor forgings. As a result of this additional experience, Westinghouse felt that with the constant advances being made in the reduction and melting practices by industry, it was time (June 1950) to place titanium into engine parts. The alloy selected was the iron-chromium-nitrogen strengthened alloy (similar to the Titanium Metal's Corp. Ti 150A). However, because of the difficulties in the actual machining of compressor discs, plus the high cost involved and the uncertainty of a continuing supply of usable material, the decision was made to slow down the effort of manufacturing titanium discs for production engines and to concentrate on solving the many problems brought to light by the early work.

These steps were taken and the results have been gratifying. Actual engine parts such as discs, blades, bolts, etc., have been and are being made from titanium and titanium alloys. Some of the parts which were made have been incorporated into engines which now have completed over 150 hours of operation. Results of these tests were so satisfactory that our future planning, as far as materials are concerned, includes titanium as a basic engineering material. This will be seen in later sections of this report.

We do not infer that Westinghouse is satisfied with the present state of the titanium art. We urgently recommend that full consideration be given to producing a higher quality sponge and uniform alloys, a cheaper product, and one

[1] A jet engine developed by Westinghouse for the Bureau of Aeronautics, Department of the Navy.

which can be manufactured as readily as the ferritic stainless steels. Attached hereto for the committee's technical study is appendix A giving a more complete idea of the problems in the reducing and melting phase of this industry. This problem in itself is probably the key to accomplishing all the points mentioned in the above paragraph.

From the discussion in the attached appendix A it is apparent that it is possible to develop low hardness, high purity sponge, and to melt homogeneous alloys so that a more usable material will be evolved. Westinghouse recommends that herein lies one field where significant results can be obtained as users cannot tolerate sponges with hardness over 140 to 150 Brinell. To accomplish this may require immediate modification of existing equipment and the starting of more development work. Industry would rather see titanium produced at a lower rate but with higher quality than at the high production rates now being forecast at the existing quality level.

It would be well to enumerate some of the advantages and disadvantages of titanium as it appears to this user at this time. On the plus side of the picture we find the following points:

(1) The ore is abundant enough to justify large-scale commercial exploitations.

(2) The density is low.

(3) The resistance to atmospheric and chemical corrosion is outstanding.

(4) Favorable strength-weight ratios are attainable for working temperatures up to 800° F.

(5) High fatigue strengths seem to be attainable by suitable alloying and heat treatment.

(6) Hot forging or forming or rolling can be readily accomplished.

(7) It appears that some of the new alloys can be arc welded.

(8) It has an attractive commercial appearance.

(9) It has a very favorable technological future development picture.

Characteristics that may or may not be desirable depending upon the circumstances are as follows:

(1) Low modulus of elasticity, approximately half that of steel.

(2) High electrical resistivity—25 to 100 times that of copper.

(3) Low thermal-conductivity.

(4) A high melting point.

The following characteristics are usually considered to be definitely on the minus side.

(1) A high chemical reactivity for gases and other metals.

(2) Is considered more difficult to machine and generally fabricate than the stainless steels now being used.

(3) Has a rapid decrease of strength and increase in oxidation rate above 800° F.

(4) Has a high cost.

This last point should be amplified to a greater extent for the future of titanium hinges upon the national defense effort. Present annual development expenditures are estimated to be at $10 million per year.[2]

This expense can be justified when one reviews the results that have been obtained during the past few years. Westinghouse is in agreement with the principle that titanium should only be used if substantial weight savings per unit dollar can be achieved. This does not always mean for rapid usage of the metal but it does mean that where titanium is used that we will see a greater chance of success for weight reductions.

Titanium sponge is presently a marketable commodity purchasable at $4.50 to $5 per pound. Forging billets cost Westinghouse approximately $10 per pound and titanium sheet about $20 per pound. Between sponge and billet are melting and other consolidation costs and attendant scrap losses. The manufacture of titanium sheet and bar stock results in a very high scrap ratio at the present time. If this scrap rate can be reduced it is axiomatic that the final cost will be reduced, resulting in a much wider application.

Now that we have traced the evolution of titanium from its very early development stages through its initial manufacturing problems, we can now state the present status of Westinghouse with respect to titanium. Titanium is being specified for use in Westinghouse gas turbines in such places as compressor disks, compressor blading, compressor through bolts, and many other miscellaneous parts. The extent that it will be used will depend on how much the ultimate

[2] Symposia on Materials and Design for Light Weight Construction, Titanium Seminar, Aug. 6, 1952.

user is prepared to pay for it. Titanium is an expensive metal, it is costly to handle in the shops, there are attendant time delays due to increased manufacturing time which means more machine tools and increased engineering aids which the manufacturing departments need to successfully produce components.

Technically, titanium can be used in increasingly large amounts. The Westinghouse Electric Corp. estimates it will use the following amounts of titanium in the next year, if the end user can justify the cost:

(*a*) Forty-one tons of bar, billet, and sheet (requiring 58 tons of sponge) per month for the first half of 1954.

(*b*) Approximately 55 tons of bar, billet, and sheet (requiring 90 tons of sponge) per month starting July 1954.

Approximately 28 percent of the titanium forgings currently received are rejected, indicating that the quality leaves much to be desired. These high rejection rates must be reduced if the designer is to develop confidence in its use in such vital applications as jet-engine parts.

The use of titanium in jet engines results in important weight reductions depending upon the extent to which titanium substitutions are made. For example, in our important weight-reduction program, the maximum use of this alloy can reduce the engine weight 90 to 100 pounds with specific savings of 8 pounds per compressor disk and 4 pounds for 2 stages of compressor blading. Before seriously considering the maximum possible use of titanium, Westinghouse wants to be assured of a continuing supply. It is felt here that a word of commendation can be given to APRA of Wright Field who have followed the titanium production picture closely. Necessary data can be quickly obtained by the user from this agency to determine the feasibility of initiating large-scale titanium-substitution programs. It is important that a service of this type continues as long as titanium is in its embryonic stages.

As far as future planning goes we can say that our engines that are still on the design boards incorporate titanium to a larger extent than is presently conceived. This is being done with the idea in mind that reduction in costs will be made within the next few years.

As an example of our future thinking, we are evaluating at the present time several new titanium alloys which seem capable of being used as turbine disks. These alloys are classified as an all-alpha-type material. However, it is only possible to obtain these all-alpha-type materials by starting off with a low hardness, 140 Brinell sponge. Some of the sponge that is now being obtained does not meet this restricting qualification. Steps should be taken to remedy this situation since the all-alpha-type alloys are the ones to which metallurgists and designers will look forward to for their future design materials.

In the preceding discussion we have delved into the applications of titanium for mainly military usage. Recently, one of the divisions of Westinghouse has made a careful survey as to the potential demand and the value of titanium on a civilian level. It is thought that some of the results of this survey should be mentioned here. Westinghouse feels that titanium is here to stay and is now designing ore reducing and sponge-melting furnaces for the industry. A commercial application of titanium which is based on a unique combination of physical properties of titanium will, if proven successful, result in the consumption of a fairly large amount of the metal. Another application for a titanium alloy would be as a weight-supporting core for electrical conductor spans as a replacement for steel now used. Calculations show a 16-percent weight savings per foot and a saving of $10,000 per mile of span.

A promising application for nonmagnetic titanium alloys would be for rotor-slot wedges in 250,000 kilovolt-ampere generators where a high yield strength at moderately elevated temperatures is desired. Large generator retaining rings up to 40 inches in diameter could be made of the titanium alloy having a yield strength of 150,000 pounds per square inch and 10-percent elongation now achievable if the cost did not exceed $5 per pound.

Forged titanium alloy blades are also being considered for blading in low pressure steam turbines. Consideration has also been given to using titanium blades in land gas turbines. Since such turbines use a low-grade fuel, it is necessary to have a highly corrosion resistant material to withstand the attack of the sulfurous acid formed by the combustion of the fuel.

If titanium can be surface hardened on a commercial basis there should be many applications for rotary seals in the chemical industry as well as in other rotating parts that demand high strength/weight ratios.

In conclusion Westinghouse at the present time is using titanium only in its aviation gas turbines. The quantities have been forecast earlier in this state-

ment. These quantities will not only increase in gas-turbine usage but in civilian applications, as mentioned above, if the cost can be lowered and quality increased. It is hoped that this presentation of the attitude of Westinghouse with respect to potentiality of titanium is helpful to the committee in seeking the answers they are trying to obtain as to the potential demand and the value of titanium. If there is other information which is required to complete this picture Westinghouse will be glad to cooperate fully.

APPENDIX A

It was mentioned earlier in this report that full credit should be given to Dr. Kroll in establishing the basic technology of the titanium industry. The main advantage of the Kroll process over the various alternative reduction processes operating at a competitive cost level results from the fact that one of the principal intermediates, titanium tetrachloride is a liquid that may be extensively purified by conventional chemical processing methods. The other principal intermediate, metallic magnesium, is also commercially obtainable in relatively pure form. The problem of avoiding contamination and thus obtaining a high-quality product is concerned with only those steps of processing that follow the preparation of chemically pure titanium tetrachloride. These are (1) Magnesium reduction of the titanium tetrachloride to form a metallic titanium sponge, and (2) the melting and casting of the sponge to form ingots, both pure titanium and titanium alloys. The prevention of contamination during the magnesium reduction cycle is possible only when sufficient care is taken to employ clean reaction vessels of the proper material and proper design.

Contamination by iron which is tolerable in some instances, but certainly not in all, appears to result principally from the use of iron reaction vessels that are attacked by the reaction mixture. Contamination by oxygen and nitrogen results from improper choice of construction materials, improper vacuum design and inadequate procedures as regards to cleanliness, evacuation, and purging.

We believe that all of the above deficiencies may be corrected by the proper application of established design and practices. It is believed that such improvements will gradually be made with regards to such practices by the present titanium-sponge producers. Although the immediate effect of their application will be to increase the net cost per pound of the resulting titanium sponge, the overall effect should decrease rejection rates and increase the utilization of scrap.

Once sponge leaves the reduction furnace, the major problems result from the presence of small amounts of magnesium chloride in the numerous pores of the sponge. The bulk of this byproduct may be eliminated by high-vacuum treatment at temperatures above 900° centigrade. Again proper selection of materials for the necessary vacuum-treating vessels and adequate vacuum design are important.

The finer traces of magnesium chloride are never completely removed, however, by even the most intensive practices, it remains in the pores of the sponge until the sponge is finally melted. This magnesium chloride is extremely hygroscopic, and begins to absorb significantly large amounts of moisture from the atmosphere as soon as the fresh sponge is first exposed to standard atmospheres.

The moisture accompanies the sponge into the melting furnace and is there converted essentially into interstitial oxygen and hydrogen impurities, both extremely troublesome in all phases of the manipulation and manufacture of titanium parts.

For the prevention of this moisture introduction, careful procedures and special equipment such as air dehumidifiers are again essential. These provisions are conventional in many chemical industries but have probably not as yet been employed in the titanium industry to the extent that will eventually be both necessary and economically feasible.

In the melting and casting of titanium there is as yet no known slag or other additive that will scavenge impurities for melting titanium. In this operation also, quality control consists primarily of preventing the exposure of the metal to contaminants. In the case of atmospheric contaminants, such as oxygen and nitrogen, this precaution is accomplished by adequate vacuum design of the melting and casting furnace, coupled with careful purification of whatever inert atmosphere (argon or helium) that might be used.

In the original melting furnaces for making massive ingots, graphite was employed as a crucible material, because it appeared to exhibit the lowest tendency

of all available refractories to dissolve in molten titanium. Even so, the average carbon content of ingots melted in this manner was from 0.75 percent to 1 percent which is considerably higher than is tolerable for practicable forgeability, weldability, and machinability. This irresolvable difficulty of melting in refractory crucibles was circumvented by the introduction of the chilled mold arc casting furnace for large capacity melting and casting. In this furnace titanium sponge is melted by the heat of the energized electric arc propagated between the molten bath and the electrode above it, and the metal is cast in a strongly water-cooled copper mold that also acts as the crucible. Although the copper mold introduces no appreciable contamination, new difficulties resulted from the use of tungsten or graphite nonconsumable electrodes in these original arc furnaces. The residual magnesium chloride in the sponge, being highly volatile at the melting point of the titanium, produced considerable spatter that resulted in coverage of the electrode with molten metal. The electrode was progressively eroded due to the formation of relatively low-melting eutectics which drain back into the bath thus contaminating it with tungsten or high carbon-bearing titanium.

An additional difficulty encountered in the use of nonconsumable electrode arc furnaces is the inhomogeneity of titanium alloy ingots produced by this process. The only satisfactory way found thus far for obtaining the necessary homogeneity is by double melting of the ingot, that is, first introducing the metal to the arc furnace and then melting and casting a second time. In the nonconsumable electrode furnace, remelting can be accomplished only by diminuting the first melt ingot into relatively fine chips and feeding this material back into the melting furnace, an extremely tedious and expensive operation.

Both of the above difficulties of melting in the nonconsumable electrode furnace are mainly overcome when the sponge is consolidated in the consumable electrode arc furnace. In this case the sponge is compacted by conventional powder metallurgic processes to form a continuous electrode which is then melted or consumed as the principle source of feed material for the ingot. Contamination by tungsten or graphite is eliminated completely. The resulting ingot is readily remelted as the consumable melt of a second operation either after reducing by manipulating and then feeding back into the first melt furnace, or by feeding in the as-cast condition into a larger second melt furnace. The required degree of alloy homogenization can therefore be obtained with a minimum of additional labor and operating expense.

The use of this new type furnace, only recently developed and introduced by the Bureau of Mines, constitutes the greatest improvement in the process metallurgy of titanium alloys in the past several years. Now that this process has been shown to be a commercially feasible operation the final major deterrent to effective control over the quality of finished products seems eliminated. It is reasonable to expect by the users of titanium that the titanium industry will make use to the utmost extent, the principles established by Dr. Kroll and the Bureau of Mines as well as incorporating techniques established in the chemical industry in the past. It is important that the titanium sponge that is produced in the future is of the highest quality and titanium alloys which are made from this sponge are of higher quality than has been available up to the present time.

Senator MALONE. Does that complete your statement?

Mr. MOCHEL. Yes.

Senator MALONE. Does your associate have anything to add at this time?

Mr. GOLDBERG. No, sir.

Senator MALONE. I hope, Mr. Mochel, if you have any further information, that you think would be helpful to this committee, our report will be prepared right after the holidays, that you would—that is, for the full Senate committee—that if you would furnish us an additional brief on any point that you figure would be helpful to us——

Mr. MOCHEL. We will study the matter and may submit something.

Senator MALONE. Thank you very much.

I regret we were not able to finish tonight. We will continue at 10 o'clock in the morning, and finish, I am sure, by noon tomorrow.

(Whereupon, at 5:30 p. m., the committee recessed to reconvene at 10 a. m., Wednesday, November 25, 1953.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

WEDNESDAY, NOVEMBER 25, 1953

UNITED STATES SENATE,
SUBCOMMITTEE ON MINERALS, MATERIALS,
AND FUEL ECONOMICS, OF THE COMMITTEE ON
INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to recess, at 10 a. m., in the committee room, 224 Senate Office Building, Senator George W. Malone, Nevada (chairman of the subcommittee), presiding.

Present: Senator George W. Malone, Nevada.

Present also: Jerome S. Adlerman, counsel to the subcommittee, and George B. Holderer, committee engineer.

Senator MALONE. The committee will be in order.

Mr. Wyatt, of the Crane Co.

Mr. Wyatt, you are familiar with the objectives of the committee. You have heard part of the hearings. If you have a written statement, you may proceed to read it, or comment from it and submit it for the record, or you may proceed in any way you see fit.

STATEMENT OF E. E. WYATT, EXECUTIVE ASSISTANT TO THE PRESIDENT, CRANE CO.

Mr. WYATT. My name is E. E. Wyatt, executive assistant to the president, Crane Co.

Crane Co. has engaged for several years in laboratory and pilot-plant work on titanium. For approximately 2½ years past it has been operating a pilot plant in Chicago. As of July 31, 1953, Cramet Inc., a wholly owned subsidiary of Crane Co., contracted with the then Defense Materials Procurement Agency, which is now a part of the General Services Administration, wherein Cramet agreed to construct a plant capable of producing titanium sponge at the annual rate of 6,000 tons per annum.

This plant is now under construction on a site near Chattanooga, Tenn. The property has now been graded. Two buildings, together with roads and parking areas, are now well under way, with other detailed plans to be released shortly for further construction to be started on the site.

The plant will be constructed in 4 self-sufficient units, each having a 1,500 net ton annual capacity. This will enable the starting of production immediately after one unit is completed, while the balance of the plant is still under construction.

The general layout of the plant is such as to allow for subsequent expansion up to a possible quadrupling of presently planned capacity.

Senator MALONE. What is the planned capacity?

Mr. WYATT. 6,000 tons.

Senator MALONE. Per year. What does that mean in terms of daily production?

Mr. WYATT. In the neighborhood of 17 tons a day. This will be an around-the-clock operation, and we propose to run it 7 days a week. Production will start in this plant in April of 1954, in a control plant now well under way and construction. This control unit will only have a nominal production capacity. Production from the first unit of the main plant is scheduled to start during the third quarter of 1955.

Senator MALONE. About 2 years.

Mr. WYATT. Yes. Wait a minute, Senator. No, I am in error on that. That is the third quarter of next year.

Senator MALONE. 1954.

Mr. WYATT. Yes.

Senator MALONE. Just about a year from now.

Mr. WYATT. That is correct, with the second unit going into production during the first quarter of 1955, and the remaining two units during the second and third quarters of that year.

Senator MALONE. That will then reach full capacity of 6,000 tons per year.

Mr. WYATT. That is correct. During 1954, production of course will be relatively small because of these units going in late, but in 1955, we estimate the production of 2,900 tons of sponge, and, of course, 6,000 tons annually thereafter.

This plant is being constructed so as to be able to produce ingot, starting with raw materials readily available on the North American Continent. A modified Kroll process is to be employed.

Senator MALONE. When you speak of raw materials in the North American Continent, what do you mean? Ilmenite?

Mr. WYATT. It will be capable of using slag produced as you heard from the testimony given yesterday.

Senator MALONE. Ilmenite slag?

Mr. WYATT. Yes.

SHOULD NOT DEPEND ON IMPORTS

Senator MALONE. You feel there will be plenty of raw materials in the North American Continent?

Mr. WYATT. We feel quite assured that there is adequate supply of raw material on this continent.

Senator MALONE. Why would you be particular to have your raw material source on the North American Continent?

Mr. WYATT. For two reasons. First, we feel that the economics involved may dictate such a course, and secondly, we feel that the only assurance of continued production is with such a philosophy.

Senator MALONE. Why?

Mr. WYATT. As has been brought out so many times, very properly and correctly, we believe, we do not want to depend on raw materials

coming over either 1 of the 2 oceans. We are quite familiar with the many sources of supply of ilmenite and rutile in other parts of the world. At the same time, we have a great confidence that there will be additional sources of supply coming in, not only in Canada, but also in the United States.

Senator MALONE. Do you have any qualms about securing raw material in the event of an all-out world war if it were from foreign nations?

Mr. WYATT. Obviously we do have qualms of getting it from foreign nations, definitely. After all, the impetus on the titanium is on behalf of a strong defense, obviously leading to the conclusion that we believe it would be foolhardy to contruct any plant that was not capable of using domestic materials.

Senator MALONE. Do you have any misgivings about a foreign country even in peacetime regulating its exports?

Mr. WYATT. We do not want to be in a position of having to depend on them.

Senator MALONE. There is a record of such regulation.

Mr. WYATT. Yes.

Senator MALONE. I believe it has been outlined in testimony that India, to mention one, had closed down the export of ores or sands that were used in the manufacture of titanium. You think it would be ill-advised to depend on any foreign nation across major oceans for a material needed in national defense?

Mr. WYATT. The answer is definitely "Yes." It was for that reason that we have planned this plant so as to be capable of using domestic materials, the supply for which we feel is entirely adequate, for at least as reasonably a long period in the future as we think one ought to consider.

Senator MALONE. You are familiar with the general policies laid down by a former President, Mr. Truman, that the policy of the Nation was to secure minerals from foreign sources and save our own. In fact, we are now dependent on foreign shores for many of these minerals and materials that it would be difficult to fight a war without. You are cognizant of that fact?

Mr. WYATT. Yes; I am.

Senator MALONE. Go ahead.

Mr. WYATT. In our Government contract, Cramet may obtain advances up to a maximum of $24,950,000 from which this facility is to be constructed. These advances are to be repaid at 5-percent interest over the period of the contract, which period will probably approximate 5 years. There are so many different alternative methods there, but to simplify it, the repayment period would approximate possibly 5 years.

We obviously have a great confidence and faith in titanium, or else we would not have voluntarily expended the substantial sums of money we have, nor would we have taken the risk, and there is a great risk if one does not have confidence, in going into a plant even under advances from the Government to construct the plant. There are many millions of dollars required for working capital. There are possibly millions of dollars involved in operational losses before economic production is estabished, which any company going into a

facility such as this must recognize. Had it not been for the great confidence which we have we would not obviously have voluntarily entered into this picture.

The Crane Co., as you know, has been in the metals business for what within a couple of years will be a century. We feel we know something about metals, and we certainly have confidence that the problems on quality and operational difficulties will definitely be resolved.

Senator MALONE. The Crane Co. has always had a mighty fine reputation, and many of us are glad to see them get into this field. You feel that the civilian use, even though there was no war, would eventually justify your getting into the business in a substantial way?

Mr. WYATT. We do not believe that the civilian use would justify entry into production with the present status of technology to the extent that we are now constructing a facility in Chattanooga. We do feel, however, it justifies the development work done. It would definitely justify a smaller facility, and we feel eventually the civilian market, once technology is improved to a greater extent than it presently is, definitely would justify a substantially larger facility than we are now constructing.

Senator MALONE. Of course, the civilian consumption naturally would grow as the price would be reduced.

Mr. WYATT. Very definitely.

Senator MALONE. Do you feel that the price will be reduced as you get into volume production in the future?

Mr. WYATT. Even with present technology and present plans, Cramet voluntarily reduced the price to the Government on its portion of its take, and it has an option of 25 percent of the capacity over 5 years, to $4 a pound for all but the first year.

Senator MALONE. That is the contract. You receive $4 a pound after the first year.

Mr. WYATT. That is correct; $5 for the first year, and $4 for the second and following years.

Senator MALONE. Is the contract so written that you are bound to deliver to the Government, or do you deliver to any private market?

Mr. WYATT. We have the right under our contract over the period of the contract to deliver to the Government up to a total of 6,000 tons. That is 1 year's capacity at the prices I mentioned. The Government has the option to purchase up to 25 percent over that same period.

Senator MALONE. Twenty-five perecent of your production?

Mr. WYATT. Yes; but in the Government's option, the combined total which the Government has the privilege or must take cannot exceed 7,500 tons.

Senator MALONE. Supposing you are unable to dispose of it in the market at the contract price, is the Government bound to take it then if you offer it to them?

Mr. WYATT. The Government under the contract would be so obligated to take up to 6,000 tons over the life of the contract, yes, at the prices mentioned.

Senator MALONE. At $5 per pound the first year, and the following years at $4?

Mr. WYATT. That is correct, sir.

Senator MALONE. Go ahead.

Mr. WYATT. I am through with my particular statement here. We, as you know, are just getting into this business. I would be very happy to answer any questions you or anyone else has.

Senator MALONE. I do not believe we have any questions. You are just starting. You have every confidence that you will get into production on the dates mentioned and specified in your contract.

Mr. WYATT. The dates mentioned here are much improved over the contract. We are now ahead of schedule substantially.

Senator MALONE. That is good news. You will be ready to expand, if necessary, and if the market justifies or if the contract with the Government justifies it, to quadruple your contract production of 6,000 tons a year?

Mr. WYATT. We certainly would be very pleased to consider. We cannot obviously make any commitments, but obviously from the type of planning which we have made, it would indicate, and certainly we will assure you of our desire to cooperate and give very serious consideration, to subsequent expansion.

Senator MALONE. I understand at the beginning of your testimony that you are planning for a structure that would permit four times the original production.

Mr. WYATT. The layout of the plant is such that it can be added to on the presently graded site, using the services which go into the plant. An expansion up to quadruple the present capacity could be accomplished. We are not putting in these facilities for that.

Senator MALONE. I understood that. But you are planning that if the market justifies it, you can expand.

Mr. WYATT. That is correct.

Senator MALONE. I was very much interested in the testimony in Los Angeles of Mr. Holloway. I was impressed also with his apparent knowledge of the situation, and understanding of the market as it now exists, and his estimate of the future market.

That is all, then, Mr. Wyatt, and thank you very much for your appearance. If you have anything further to offer that you think would be helpful to the committee, we would appreciate a brief on the subject. Just mail it to the chairman.

Mr. WYATT. Thank you, sir. It has been a pleasure being here.

Senator MALONE. Mr. Stalker, of General Electric Co. Mr. Stalker, you also represent a very famous company, famous for its successes in the fields in which it has invested its money. You know how to manufacture articles when you turn your attention to them. I am glad to see you are interested in this matter.

Will you identify yourself for the record, and make any statement you care to, written or otherwise, that you think would be helpful to the committee.

STATEMENT OF K. W. STALKER, JET ENGINE DEPARTMENT, ENGINEERING SECTION, AIRCRAFT GAS TURBINE DIVISION, GENERAL ELECTRIC COMPANY

Mr. STALKER. My name is K. W. Stalker, from the Jet Engine Department, Engineering Section, Aircraft Gas Turbine Division, Gen-

eral Electric Co. I have prepared a statement which would read as the title, "Titanium—Past, Present, and Future—at the General Electric Company."

Most of the titanium work done at the General Electric Co. has been done in or for the aircraft gas turbine division. Our product is jet engines. In order to make you more familiar with some of the parts of a jet engine, I have brought along a cross sectional cut of an engine. This is exhibit 1.

Senator MALONE. It will be accepted as exhibit No. 1 and made a part of your testimony.

(The document referred to was marked "Stalker Exhibit No. 1" and is on file with the committee.)

Mr. STALKER. In June 1948 we at the General Electric Co. received our first pieces of metallic titanium. The material was in the form of both bar and sheet. We conducted several laboratory studies on the material and made a few engine parts. The material displayed some interesting characteristics. It was relatively light and fairly strong. It looked like a good potential material for making jet engines.

Senator MALONE. What date was this?

Mr. STALKER. June 1948. Therefore, in early 1949 we purchased enough material to make one stage of compressor blades. I have some sample compressor blades which I would like you to see.

Senator MALONE. Do you wish to submit one of these blades as an exhibit to the committee?

Mr. STALKER. Yes. You may keep those.

Senator MALONE. It will be marked "Exhibit 2," and filed for the benefit of the committee study.

(The blade referred to was marked "Stalker Exhibit No. 2" and filed with the committee.)

Mr. STALKER. We also made some outer combustion chambers and other miscellaneous parts. The compressor blades were installed in a test engine and operated for several hundred hours. They operated satisfactorily.

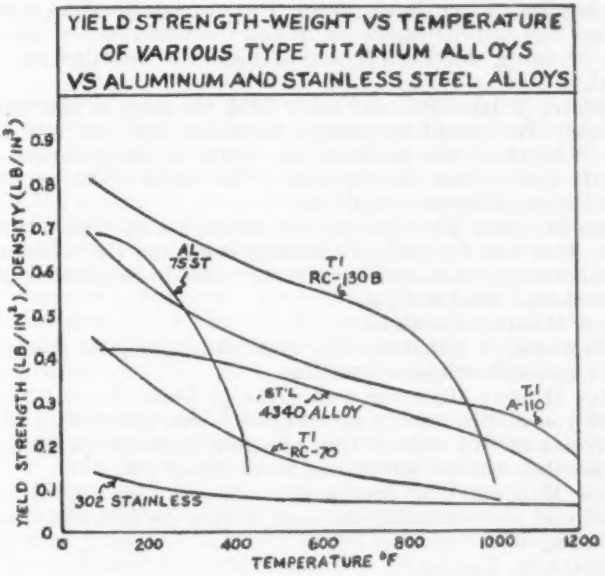
Our early evaluation was that its strength-weight ratio was only fair when compared to alloy steel. The welding properties were only fair to poor, but other fabrication properties were fairly good. Therefore, we anticipated that alloyed titanium would be suitable for some of the highly stressed parts.

In 1950 we began work with our first commercial alloys. They were from 50 to 100 percent stronger than the purer metal. This was good. The alloying elements gave the material a fairly good temperature range.

As exhibit 3, I have a chart which we use in our engineering works showing the yield strength-weight ratio relationship at temperatures.

Senator MALONE. That may be received as exhibit No. 3 as a part of your testimony.

(The table referred to was marked "Stalker Exhibit No. 3" as follows:)



Mr. STALKER. If you will observe the chart, you will see RC70 at the bottom of the chart is what we call commercially pure titanium. At approximately 400°, the line crosses with the aluminum chart. Titanium would become appealing in relation to aluminum, then, at 400°. But you may also observe that 4340 alloy steel, heat treated and tempered at proper ranges, shows a distinct density advantage beyond about 350° over any of the material except the alloyed titanium. Therefore, we began our work in 1950 using alloyed titanium.

We did not expect, though, that the alloyed titanium would present us with so many problems. It was extremely brittle when welded, difficult to machine, difficult to form, and had very poor ductility. We began to realize that we had many major problems to solve if we were to use alloyed titanium in jet engines.

We broadened our operating base to handle the problem. We assigned full-time laboratory personnel to the job. We set up a group of manufacturing experts to work out the problems of fabricating parts out of the material.

In 1952 we had set up sufficient material standards, processing standards, and design standards, sufficiently satisfactory to plan the use of the material in our product. But there was not enough material for our program. We had plans for a fairly broad program.

When we entered orders and when we began to get promises of delivery, there just was not enough material for our program. We, therefore, had to go back to our original materials.

Senator MALONE. What date was this?

Mr. STALKER. In the early part of 1952. Also, about this time a new development almost terminated our desires to use the material. Many of the parts began to fail. After parts were operated for a long period of time at temperature, the material lost its ductility.

It had become as brittle as glass. In our metallurgical terms, we would say age embrittlement set in and the material lost its characteristic of being ductile. It was a time for reevaluation of the material.

Therefore, in late 1952 and early 1953 we came to the following conclusions: We would not design titanium into our new engines per se. Therefore, the material was more or less returned to the laboratory for further development. We would make applications only as the supply became available.

Senator MALONE. Then you had two reasons at the time to cut down the use. One was the lack of titanium itself and the other was the matter of changed characteristics of the metal in continuous use.

Mr. STALKER. That is right.

Senator MALONE. Go ahead.

Mr. STALKER. A different alloy was made available that did not have the age-embrittlement problem.

Senator MALONE. In other words, the problem of availability for the work you had in mind was whipped. You solved that problem.

Mr. STALKER. We solved the age-embrittlement problem. The supply problem was not solved, and is not solved yet.

Senator MALONE. Will you in your statement give us an idea of how much of the material you need if you go into the design of engines using it?

Mr. STALKER. Yes, sir.

Senator MALONE. Go ahead.

Mr. STALKER. Now, we are more or less using the material as it becomes available and plan to use more as it is made available. We are now in the position to be able to purchase material to our specifications and depend on getting a product that is reliable. We are becoming familiar with titanium as a metal so that we can have it perform like aluminum or steel or the common known materials.

Today we are shipping engines with titanium parts. We have had a steady flow of material through our shops and at an ever-increasing rate. We are actively incorporating more titanium in our products as it becomes available. Today our evaluation of titanium is that it has many limitations. They are: it is expensive to purchase as a material, to process and to control. It has poor welding qualities. It has low ductility.

Senator MALONE. It has poor welding qualities?

Mr. STALKER. Yes. It has an affinity for any of the known gases generally common in the air. All of those gases contribute to poor ductility and brittleness. Also it is notch sensitive. What we mean by notch sensitive is some materials if you would make a notch like my pencil pulled apart here, drop a weight on it or have an impact load, some will bend. Titanium is inclined to fracture like glass; even though it may have ductility in tension, it would be brittle.

It had the one virtue, though, that often still makes it very appealing, in that it is both strong and light. Therefore, we have several programs working with the goal in mind to find solutions to the problems we have just mentioned. Of course there are 2 or 3 problems we cannot solve singularly. They are the price of sponge and the quantity of sponge and the quality of the sponge, or quantity and quality of material. The problem of getting a higher quality

sponge seems to be the major problem facing the titanium industry today.

SPONGE QUALITY

We have spoken of quality and quantity. I would also like to emphasize the quality. Many of the processing problems we have today are caused by poor quality sponge. Many of the laboratory solutions that we worked out failed in practice because the commercial material did not have the quality of sponge used in the laboratory materials. Today we are finding quality more of a limiting item than quantity. Our future plans for titanium are relatively firm in that we are learning to use the material. Also we are counting on progress to be made in the future as in the past. I would say in the last 3 years we have gone from a position of what you might say was being able to identify the material until today we are able to say to our engineers, "We can design titanium for this part, but we should not design it for that part."

We know the material like we know aluminum or steel. Therefore, we forecast a definite use in our future engines, especially with the advent of some of the new high-temperature alloys that have some welding properties. We are hoping that the price will come down when we begin to use the material in larger tonnages. We will insist on improved quality so that we do not have to maintain such rigid inspection and testing procedures.

Presently on our titanium parts such as forgings, every piece is prepared with a test coupon. I would say the testing cost per compressor wheel is almost equivalent to the cost of a steel wheel. I should say that over again. The cost of testing the materials in material control on the titanium forging is almost as high as the price of the steel forging counterpart.

Senator MALONE. Are you saying that it is just about the same as testing the steel counterpart or the cost of making the steel counterpart?

Mr. STALKER. The cost of testing the titanium part is almost equivalent to the price of the steel part. In steel we can set up quality control because it is a fairly uniform product.

Senator MALONE. So the testing of titanium in addition to the cost of producing titanium parts, makes quite an additional cost.

Mr. STALKER. Yes; because on every compressor wheel, we pull test specimens, we keep a case record of that wheel all the way through the processing line, and since it is not a material today that is uniform in quality we cannot set up our statistical controls like in other materials.

Senator MALONE. Uniform quality control would whip that problem largely.

Mr. STALKER. Yes. That is why I speak of quality. We realize that the supply is limited, and inadequate to meet the forecasts as outlined, but we do recommend that the supply be increased with the one reservation that quality of material must come ahead of quantity, or we will be faced with a supply of material that we cannot use in our jet engine program.

That is my formal statement, Senator.

Senator MALONE. I think it is very good. Coming from an organization, such as yours, that is entirely reliable and has long experience, it is very valuable to the committee.

You have heard the testimony over the past couple of days. What would be your general conclusion, if you have studied it, as to the expectancy in quality control?

Mr. STALKER. I would say if instead of shooting for quantity we would pay particular attention to quality, we can get out of that problem fairly quickly.

Senator MALONE. You heard the testimony the day before yesterday of representatives of the Du Pont Corp.?

Mr. STALKER. No, I was not here Monday, sir.

Senator MALONE. I think he testified, if I am not mistaken, that they are having very little trouble with quality control on their 2½ tons per day.

Mr. STALKER. Yes; I am familiar with their product.

Senator MALONE. Is it very good?

Mr. STALKER. We are satisfied with it.

Senator MALONE. Still they have some problems in quality control, and improvement in even their quality, which would make it more available to you.

Mr. STALKER. Yes. Most any of the batch processes, as far as I understand, result in occasionally a batch going sour. The general practice today is to take the harder sponge and blend it with the good quality sponge, and try to make a satisfactory product out of it. When we take our metals apart in our analysis, we can read that just like you can read a chart on the wall.

Senator MALONE. You can tell they have done just that?

Mr. STALKER. Definitely. They do not fool us a minute. What they do is vary the alloy content. You look at this curve here on the RC130–B, and the fellow that converts that into the ingot to make the billet for our forging knows how to vary the alloy content so that your tensile properties and yield strength look good.

Senator MALONE. It looks good from the factory's standpoint.

Mr. STALKER. That is right. It meets specifications. But when you put temperature on it as we have in the jet engine, it has a different curve than you have if you had not the oxygen and nitrogen contamination. Do you follow me?

Senator MALONE. Yes.

Mr. STALKER. The quality of sponge can be adjusted so a room temperature will give you the specification, but will not meet the specification at high temperature.

Senator MALONE. In other words, it just comes back to the problem—and the committee is making no attempt to understand the technical details—all we are going to study is the conclusions of organizations like your own—that is the problem in a batch process of making the sponge. The real problem is to keep the oxygen out of the material.

Mr. STALKER. Yes, sir.

Senator MALONE. If more oxygen enters than they counted upon, and they try to mix a purer batch, your theory is that it does not mix properly and does not average properly. Instead of getting an average like you would of some other materials, so if the hardness at any temperature was correct, that your manufacturing problem would be whipped to that extent. Your theory is that it does not mix properly and it still has too much of this oxygen in certain parts of it, and it is an inferior material.

Mr. STALKER. That is basically right, Senator.

Senator MALONE. From the testimony we have had—I am not a judge because I have never been in that sort of business, and that is the reason I ask your opinion—they are working on that particular problem, and you think they will whip that problem?

Mr. STALKER. Usually if an asisgnment is given to a group of engineers in this country with latitude to operate, they will solve the problem; yes, sir.

Senator MALONE. So you are looking forward to the time in the reasonably near future when the quality will meet the specifications, and if it meets the specifications—let us assume that it does—what could you see in the foreseeable future as to the amounts that you would use of this material? Suppose all you had to do was to make the designs and include the material, the same as you do now with aluminum and steel?

GE LARGEST USER

Mr. STALKER. I would say presently we are probably the largest user of titanium in the country.

Senator MALONE. How much do you use?

Mr. STALKER. The quantities are nowhere nearly proportional to some of the things we are dreaming of. I would say next year we should use probably 1,200 tons in our engines, based on our present schedules.

Senator MALONE. Even with inferior material and wrestling with that problem. But suppose by next year this problem would be satisfactorily solved and you could depend on quantity and quality, what would you use from there on, say in 1955, 1956, and 1957?

Mr. STALKER. In 1955, we anticipate with some new applications of our engines we would probably be using around 3,500 tons a year.

Senator MALONE. And would it progressively increase, and to what extent?

Mr. STALKER. It would not necessarily progressively increase, because-tonnage is in direct proportion to quantity of engines shipped.

Senator MALONE. That is true.

Mr. STALKER. I would say as we are familiar with our material, the quantity and quality becomes established, that we will definitely use more titanium in the future.

Senator MALONE. Let me ask this question in another way. All we are trying to get at is the quantity of use. How would percentages run in your engines progressively if you had it available? This of course will have to be your opinion.

Mr. STALKER. We have studied our application work up to probably 1958 or 1960. We have a fairly good picture of how we would like to use the material in the future. As a rough estimate, I would say probably 20 percent of our jet engine could be in titanium if the material was proper.

Senator MALONE. What do the engines weigh?

Mr. STALKER. They vary according to the thrust ranges. As a general figure used in the jet business three to four thousand pounds is a good rule of thumb.

Senator MALONE. If you had a 4,000-pound engine, you would be using 1,000 pounds of titanium.

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Mr. STALKER. Roughly; yes, sir.

Senator MALONE. You have already looked forward to that project?

Mr. STALKER. Yes; that is finished weight. You see, finished weight versus gross weight varies probably around four on a jet engine.

Senator MALONE. Will you explain that, General? You did once before. The total amount of titanium required to produce the finished weight of 1,000 pounds in an engine.

General METZGER. As I understand it from the statement you just made, your yield is about 25 percent finished weight.

Mr. STALKER. Yes, sir.

General METZGER. It takes 4 pounds of titanium metal in shapes and forms to produce 1 pound of engine shipping weight. So if the 20-percent figure, as I understand, which was quoted here, is equivalent to 1,000 pounds of shipping weight of the engine, it would require 4,000 pounds of titanium to produce that. Is that correct?

Mr. STALKER. Yes, sir.

General METZGER. That is, of titanium metal. Using the 60-percent yield on sponge, we can convert it back as I attempted to do yesterday.

Senator MALONE. Instead of 4,000 pounds, then, you would have 40 percent more.

General METZGER. In the sponge.

Senator MALONE. 1,600 pounds more. Finally you arrive at 5,600 pounds for 1,000 pounds of engine?

General METZGER. No, sir; you would have around 7,000 pounds.

Senator MALONE. You are right. You would have around 7,000 pounds of sponge metal required for 1,000 pounds finished engine.

General METZGER. Under the present manufacturing losses. However, there is every reason to believe, in my opinion, as quality improves and the technical advances are made in machining, forming, and working of the metal, the processing losses will decrease. Do you agree with that?

Mr. STALKER. Yes, sir. We have made tremendous strides even in the last year.

Senator MALONE. The testimony throughout shows that at least in the belief of the experts the scrap will be reusable in a certain length of time, or at least a large percentage of the scrap.

General METZGER. Yes, sir. The type of scrap which would be generated at the manufacturer's level, a large part should be reusable.

Senator MALONE. But it is not now reusable.

General METZGER. In limited quantities only.

Senator MALONE. I do not want to ask you for any classified information or any business secrets, but arriving at the quantity required, what is the range of the number of engines that you might be turning out annually? Of course, that is dependent on the present rate of preparation.

Mr. STALKER. That is dependent on our customer, the Defense Department, especially the Air Force.

Senator MALONE. Could you give us some idea of your own manufacture?

Mr. STALKER. We take pride in building as many engines as the Air Force has ever asked us to accept when they want them in a hurry. I think the general is more familiar with our schedules, and he should state it, rather than myself.

Senator MALONE. If it is advisable to have it in our record. That is another question.

General METZGER. Senator Malone, we could revert to a figure and attempt to calculate the requirement against a given rate, which is within the capability of General Electric to produce. I do not know whether you have your figures available. I think you could calculate this. At the rate of 1,000 engines a month, what would that requirement be?

Mr. STALKER. At the rate of 1,000 engines a month, we would convert into about 28 million pounds of gross weight—let me get that back to tons—that would be 14,000 tons roughly.

General METZGER. Of shipping weight.

Mr. SALKER. That is gross weight.

Senator MALONE. You have converted to gross weight.

Mr. STALKER. Yes, sir.

Senator MALONE. Of metal.

Mr. STALKER. Of material required, billet, bar, and things like that.

General METZGER. That is 14,000 tons per month. Now convert that back to sponge.

Mr. STALKER. I am sorry. I did not do my numbers right if you are doing it by month. Let me recalculate again. You say 1,000 engines per month, and roughly 4,000 pounds gross weight to make 4 million pounds per month, which is 2,000 tons per month.

Senator MALONE. That is sponge?

Mr. STALKER. No; that is billet bars, and so forth. If you want to convert that into sponge, you would take 60 percent, which would make about 3,200 tons per month of sponge requirement, based on a figure of 1,000 engines per month.

General METZGER. You have therefore the estimate generally at the rate of 1,000 engines per month.

Mr. STALKER. We would not estimate that now.

Senator MALONE. That was an annual figure of 3,500 tons?

Mr. SALKER. Yes.

Senator MALONE. In sponge what would that be?

General METZGER. About 6,000 tons of sponge per month.

Senator MALONE. Per month?

General METZGER. Yes, sir. At a thousand engines per month.

Senator MALONE. That would be 72,000 per year.

General METZGER. Yes, sir.

Senator MALONE. That is good enough for the committee. What we will try to sum up in the long run after we add up all the information, is the probable use if it were available.

General METZGER. Senator Malone, it might be of benefit to the record to state that the General Electric Co. has the capability to produce 1,000 engines per month, and has produced 1,000 engines per month during the Korean buildup. That is jet engines.

Senator MALONE. Let me ask you one more question, and that is, do you consider this metal a must in the production of airplane engines providing it might be available to a potential enemy?

Mr. STALKER. Titanium will help us in getting our engine weight down. I would say we have learned a lot. We were ready for titanium when it was not ready for us. We had engines designed and tested and ready to build in titanium and then we had to go back and redesign them in steel, aluminum.

Senator MALONE. What date were you really ready?

Mr. STALKER. Late 1952 and early 1953.

Senator MALONE. If you know, and I suppose you know something about the maneuverability and speed of a plane that is dependent on weight and engine power, what advantage is it in a fighting plane to make a lighter engine or a more powerful engine for the same weight?

Mr. STALKER. It is a tremendous advantage.

Senator MALONE. Then I would just ask you this question. I know perhaps you do not pretend to be an expert in fighting planes. The general covers that field. If a potential enemy had this material and could make a lighter engine, as you know you could make if you had the material, what advantage would it give him over a plane such as we are now turning out, and what would the comparison be? What is the real advantage of this metal?

Mr. STALKER. As we outlined in our specific data there, in certain parts we can make them lighter in titanium than we can in steel——

Senator MALONE. With the same horsepower engines.

Mr. STALKER. That is right. Rotating parts weight reflects back into bearings and acceleration rate and innumerable other advantages.

Senator MALONE. It also reflects back into the frame construction.

Mr. STALKER. Yes. We always go one step further. For every pound of frame you have to carry more fuel in order to accelerate that frame to higher speed.

WEIGHT ADVANTAGE

Senator MALONE. Let us get down to a practical question, although this may be a little off center. Suppose a potential enemy had a plane that was 20 percent lighter and had all the other attributes; it could carry more fuel to that extent or more bombs or whatever was necessary; would that be a distinct advantage?

Mr. STALKER. Definitely. We found that in the Korean conflict, our planes that had a thrust weight ratio that was below the MIG were just not in the air long. It was only when we began to introduce our later model planes that we were able to keep them out of our hair, so to speak.

Senator MALONE. Suppose the potential enemy next time had this material, and you agree this is the only material available now, or potentially available, that will provide for this advance that you are discussing and other witnesses discussed, suppose the enemy had this material and we did not have it to the extent we need it, would we be in that same position again?

Mr. STALKER. We would be at a distinct disadvantage; yes, sir.

Senator MALONE. Then would you say it is a must?

Mr. STALKER. Yes, sir. We have designed parts to use this material. We are quite conscious that if we do not get the material, we are going to have some difficulties meeting our weight guaranties and things like that.

Senator MALONE. We might turn out planes to the extent that we could afford 2 to 1 to the enemy, but we are losing a pilot or crew at the same time.

Mr. STALKER. We are very familiar with that, especially when you are on bomber applications, where the price of one plane is far in excess of the cost of a few pounds of material.

Senator MALONE. And the price of training a pilot, to say nothing of the pilot's life, is considerable, is it not?

Mr. STALKER. Yes, sir. That is why I am speaking of quality. We have also lost many planes because of the quality of material.

Senator MALONE. That is true. You have already said that you had no doubt that quality would be whipped within a reasonable time.

Mr. STALKER. We surely hope so.

Senator MALONE. You see no insoluble problem?

Mr. STALKER. No, sir; not at all.

Senator MALONE. As you say, when you give a definite problem to a set of engineers or scientists, they will generally come up with the answer if they have the time and money to work with.

Mr. STALKER. Almost invariably.

Senator MALONE. You have seen this array of witnesses and heard their testimony in the last few days who want to go into this business. I understand you do not want to get into the business of making the material. What you want is an available supply.

Mr. STALKER. That is right.

Senator MALONE. Do you have any doubt from what you heard that within the foreseeable future, if proper methods are used in letting contracts, that we would reach whatever volume we need?

Mr. STALKER. I believe in handling your problem of supply more or less like we are handling the problem of color television today. You remember a couple of years ago when the Communications Commission got in on picking out the right type of television system to be used for color. I believe that the solution to that should have been established the way it was recently established, where the specialists in the field from each company set up a committee and worked out a solution against specifications. Now all color television will be produced to a specification, and the people that were talking about one system versus another system are all satisfied now that we are going to come out with a good system. I think we could follow that same procedure in sponge production. I think instead of each company going out on their own spending millions of dollars which eventually reflects back to our taxpayers' money, because most all of it is written off either in taxes or defense contracts, if they would get together, set up specifications, we know the type of sponge that is required, if these people would then evaluate the processes—someone may have something to suggest from one company, others will have other suggestions—I think eventually that way we could come up with a process that would solve our quality problem and our quantity problem.

Senator MALONE. Perhaps more satisfactorily.

Mr. STALKER. Definitely more satisfactorily.

Senator MALONE. I would say this to you, however, in listening to all of the testimony—and again I am myself in a new field—that apparently there is the Kroll process and various modifications of it, all pointing toward sponge as the initial material. The ones that are working on the sponge—that is the reason I asked the question of someone the day before yesterday, I believe—du Pont had solved their problem of Brinell hardness and the Titanium Corp. had not. My recollection of the testimony is that they are not exchanging that information.

Mr. STALKER. I think that is definitely true.

INFORMATION POOL

Senator MALONE. When you understand our method of operating, there are patentable processes and each company is jealous of something it might discover. If all of the companies are working toward the sponge process, and would pool their information, I think it would be helpful. There are some processes that look good, or at least according to the testimony sound very good. I will have to consult with the General and others who know more about titanium, whether they are good. They skip the sponge process and go to the metal. Maybe the companies are pointing toward that process, and some say they are doing it—some of the chemical process and the electrolytical process. If they would get together and pool their information, perhaps it would be helpful. I would not say offhand, from the little I know technically about it, that you get very far in trying to pool the information between entirely different types of processes.

Mr. STALKER. That would come back to how we handled other problems. There is usually someone or some group of people that have worked on this problem for years that can evaluate the pros and cons, until it would be formulated in their minds after discussion which is the most appealing method to approach the problem whether we can go from titanium oxide directly into titanium metal or whether we have to go through the sponge stage, or something to that effect.

Senator MALONE. Experts have been baffled now for several years. Take Leo Harvey, some people laughed at his ideas—he lays on the table an extrusion bar made through an extrusion method, and they said it was impossible. I do not know whether it is possible in quantity or not. I did not see the work done. Of course, in operations in various fields, someone who is not frozen on certain lines of thinking comes up with a process that puts everybody in business.

Mr. STALKER. I quite agree with you.

Senator MALONE. So I very much appreciate your ideas in this regard, because you are connected with the company and you are in the work yourself, and your company does not have the reputation of playing around with their money in something that does not look like it has a future. Your testimony is very valuable to the committee.

Do you have any further information?

Mr. STALKER. I was interested yesterday when you were speaking of the potential supply of ore. I am not ready to release this to you for the record, but I would be glad to show you the survey we recently made. We believe in making a survey so we have facts to make decisions. There is nothing like facts to work from. This is a survey of the titanium resources of the world. I think I can make this available for your own use.

Senator MALONE. Not make it an exhibit?

Mr. STALKER. Not right now.

Senator MALONE. Are you talking about both rutile and ilmenite?

Mr. STALKER. That survey covers all the different types of titanium in various and sundry combinations, titanium oxides, titanium, and figure out how it is put together and shows where the sources are located.

Senator MALONE. The real center would be pretty close to the boundary between the United States and Canada.

Mr. STALKER. Yes, I think the largest supply is in the Quebec area.

Senator MALONE. Is it all right if I show this to the newspaper people?

Mr. STALKER. I would be glad to have you do so.

SUPPLY NO PROBLEM

Senator MALONE. It is a very interesting survey and I think it coincides with the evidence we have so far, that in the United States proper and in southern Canada is located all of the ilmenite type of ore that you could ever use, and much more no matter how far you go with the manufacture.

Mr. STALKER. I think the supply problem on titanium is satisfactory.

Senator MALONE. Right here at home.

Mr. STALKER. Yes, sir.

Senator MALONE. I am glad to hear you say that. That is a very valuable survey. It merely confirms, I think, from what the testimony has been.

Mr. STALKER. That covers every country in the world.

Senator MALONE. Of course, that does not conform to some of the information of Harry Dexter White in his memo to the President when he says we are out of material and we must depend on foreign nations and it would be very advantageous if we saved our own and purchased them from foreign nations, particularly from Russia.

Mr. STALKER. Yes, sir. I am very familiar with that problem. My home is in Colorado.

Senator MALONE. Now we are becoming dependent deliberately on foreign nations.

Mr. STALKER. There are two ways to be defeated. One is to be deceived. That is usually the way you are defeated and do not realize it.

Senator MALONE. One way would be to be dependent on the nations across the ocean for the material you could not fight without.

Mr. STALKER. That is right.

Senator MALONE. And you would not realize you are defeated until you started the fight.

Mr. STALKER. That is right.

Senator MALONE. I am glad to hear your idea. You are about the third witness that has emphasized you would not be interested in going into this production unless you knew the material would be available both in peace and war, and would not be subject to the whims of a foreign nation.

Mr. STALKER. We appreciate our responsibility in producing equipment for the defense of our country. When we were called upon to produce engines for the Korean conflict we had anticipated that if we are building defense products we should be in a position to build them in sufficient quantities to meet our needs. Otherwise we should not be in the business.

Senator MALONE. For many years it has been the policy to permit shortages in supply of almost every material, making it necessary to ration it and then make you come to Washington for allocations. I would like to speak as one member of the committee that we will

endeavor to be in a position next time so that no Government official can say that you can only have a certain amount of a necessary material for a fighting engine.

Mr. STALKER. We appreciate that. If you will take a look at the electrical industry in which we have played a major part in war years, that is one industry that has tried to have foresight so we have never had to ration power to any great extent, even in wartime.

Senator MALONE. For the great amount of the copper that is used, there is no reason to go outside the Western Hemisphere.

Mr. STALKER. Not at all.

Senator MALONE. If proper principles were adopted in the opinion of some of us, you might not have to go out of the northern part of the Western Hemisphere in an emergency.

Mr. STALKER. We do not expect we would, because we always approach most every problem with an alternative. If you are tied up on one item in an integrated economy, then you fail. If you have an alternative you can turn to, you usually succeed. We find in the copper industry, I agree definitely we should integrate ourselves so we can produce as much copper as we need. But we found in our electrical work we could also use aluminum. So we can assure you that we can furnish equipment based on copper now, or aluminum, if we had to.

Senator MALONE. And stay right here in our own bailiwick.

Mr. STALKER. That is the only place you ever fight when you have your back against the wall.

Senator MALONE. I say to you that you are a great comfort to this committee, and I hope if you have any further thoughts along these lines, you would send a brief to the chairman of the committee at the Senate Office Building, and we convey our thanks to your organization.

Mr. STALKER. Thank you, Senator.

Senator MALONE. Mr. Nason. From what I understand about your company, or your product, it is a unique product and the committee is interested in it from the standpoint of the amount of metal you would need if you were in production. You know the objectives of the committee. Would you proceed.

STATEMENT OF EDGAR F. NASON, GENERAL SALES MANAGER, ELASTIC STOP NUT CORP. OF AMERICA, UNION, N. J.

Mr. NASON. Mr. Chairman, I do not have a prepared statement. I have notes. I will be glad to submit a statement later on.

Senator MALONE. You may make any statement you wish.

Mr. NASON. I will outline our relation to this. Our company makes self-locking nuts, primarily for the aircraft industry. We have almost since the inception of the aircraft industry. The self-locking nut is almost a common denominator of the aircraft and engines that are built. I do not believe there is an aircraft or an engine that does not use some quantities of elastic stop nuts.

To give you an idea of the quantities, during World War II, I think we produced for the Air Forces in the neighborhood of 300 million nuts a month, which amount to a considerable amount of weight in the aggregate of aircraft.

About 2 years ago we started to develop self-locking nuts out of titanium at the request of the various aircraft companies, and at the request of the services. We released designs on one segment of our

line about 2 months ago, and we presently have inquiries from 3 of the major aircraft companies, and we have orders from 1.

I do not know if we are going to talk about quantities and pounds that come off the airframe, whether I am permitted to talk about who the people are.

General METZGER. Just eliminate the model and customer.

Mr. NASON. The No. 1 item that we have on our list as far as manufacture is concerned is for a fighter plane. Our raw material for the first plane is on order now, and is to be delivered January 15. This initial order is to determine how we are going to manufacture the nuts, or at least in what cycle time. We have already manufactured some.

Senator MALONE. Do you manufacture the bolts, too?

Mr. NASON. No, we do not. We are just concerned with nuts. That is significant, too. The requirements on this airplane in terms of number of nuts are about 1,400 pieces, which saves 150 pounds per airplane.

Senator MALONE. Just a switch in the material that you have previously used to titanium?

Mr. NASON. Just changing from a steel nut to a titanium nut.

Senator MALONE. That is in the frame?

Mr. NASON. That is in an airframe. It does not include an engine.

Senator MALONE. Translating that into total weight of 7 or 8 to 1, for 1 pound saved, results in an additional saving of around seven or eight hundred pounds or maybe a thousand pounds.

General METZGER. If the airplane had been designed for it. This aircraft was not.

Senator MALONE. I am talking about an ultimate design.

Mr. NASON. This happens to be a production airplane. It is an immediate need.

Senator MALONE. This I understand was not originally designed for these nuts, but they are being tried out to see what they will do.

Mr. NASON. My understanding is that their objective is to get a little more speed out of the airplane.

Senator MALONE. That is from the beginning of airplanes that has been the objective.

Mr. NASON. In this particular one it is immediate. It seems this is the first and the easiest way they can take advantage of titanium, because interchangeability is not involved. All they have to do is take off one and put the other on to save 150 pounds.

The requirements they have placed on us means that immediately we will need roughly a ton and a half of titanium a month. That is in alloy.

Senator MALONE. For this particular purpose alone?

Mr. NASON. For this one plane.

Senator MALONE. For this one order.

Mr. NASON. That is right, based on their present schedule.

Senator MALONE. Of course, that goes back as you have converted finished products into sponge several times, General.

General METZGER. Yes.

Mr. NASON. If this is carried on and it is already indicated to us that it will be, if the same conversion is made on what the other manufacturers are presently manufacturing, based on our current requirements, we will need roughly 50 tons a month. I would like to point

out this is just on hexagon nuts. This is just the very start. If they converted the other configuration of nuts that they use and these may be new names to some people here, anchor nuts, and so on, you can multiply that figure by 4 times, or we would need 2,400 tons a year based on our present production.

Senator MALONE. That is a surprising amount for that particular use. It is very important.

Mr. NASON. I would like to point out again that is based on our present usage.

Senator MALONE. Are you having any difficulty now in securing the material?

Mr. NASON. That is a point. Our source happens to be Rem-Cru. We are assured of enough material for this first plane's worth. Republic has assured us that for their production requirements they will be able to deliver us enough material. But if the other manufacturers make this same step, this nut will necessarily have to become a shelf item.

Senator MALONE. Spare parts?

Mr. NASON. No, a shelf item. A stock item, as far as we are concerned, so that we can ship to all the aircraft manufacturers as their requirements come up.

Senator MALONE. So what you are talking about is an inventory that you will have to keep on hand.

Mr. NASON. Yes. It will not be possible any longer then for us to depend on the aircraft manufacturer to get us material. We have tried that before. I know that General Metzger knows about our problems in getting raw material for what is called common hardware on the airplane. We will have to have individual allocations directly to our company.

Senator MALONE. You will become a substantial user of the material if this becomes established.

Mr. NASON. To give you an idea, this 2,400 tons that I am talking about now is based on present requirements, if we were manufacturing at the same rate as we were in World War II, you would multiply that by 8 times.

Senator MALONE. Then you would have practically 200,000 tons.

Mr. NASON. Almost that. No, it would be 20,000 tons of metal.

Senator MALONE. Then I have multiplied it wrong from the beginning. You said 2,400 tons per year.

Mr. NASON. If we convert the rest of the line which is inevitable.

Senator MALONE. That is right. I added a cipher.

Mr. NASON. That is dependent upon our ability to form this material to conversion to the other types.

Senator MALONE. About 17,000 tons of metal to meet the World War II peak. Do you have any doubt with your knowledge of the material that this is a practical application?

Mr. NASON. We have done 2 years of testing. There is no question about it. The fact that standard sheets by the aircraft companies are already being prepared for it I think indicates that. You see, we are not the criterion. We design the nut to the best of our ability. We take into account as many engineering factors as we know, but the aircraft manufacturer actually is the one that determines whether the nut is suitable for use.

Senator MALONE. He is the last word.

Mr. NASON. He is the last word.

Senator MALONE. I am just curious about it. Let me ask you, what is the bolt made out of?

Mr. NASON. They are going to be used initially on steel bolts because the technology of the bolt is not quite as far along as it is with the nut. Eventually they expect to use them on titanium bolts so there will be additional weight savings.

Senator MALONE. What is the coefficient of expansion of titanium as compared to steel, or does that have any bearing on the fitting of a titanium nut to a steel bolt?

Mr. NASON. It would not be of enough significance here to affect the application. We have tested them at the extreme ranges of temperatures that they will be exposed to. Actually we have tested them in one form or another at the limiting temperatures of titanium on both steel and aluminum bolts, and they appear to be satisfactory.

Senator MALONE. Do you have any further statement?

Mr. NASON. I would like to point out that in making or in doing this work for these nuts with titanium, we have gone along the lines of designing parts that would make the most economical use of the material. But when we do that, we are straying away from the international standards that have been recently set up insofar as configuration of the nut is concerned. We have tried to reduce the diameter of the nut to its irreducible minimum from a weight point of view.

Senator MALONE. Or for the strength required.

Mr. NASON. Yes, for strength. But when we do that, we end up with a 12-point nut instead of a 6-point nut.

Senator MALONE. Explain the difference.

Mr. NASON. A 6-point nut is a common hex nut that you would use on your automobile and the nut you have in your hands is a 12-point nut. The 12-point nut conforms to the inside of a standard 12-point socket. Wrenching is no problem, but when you reduce it to the irreducible minimum you need more points on the nut to support the wrench. There is an attendant saving here because as we reduce the wrench diameter, it means that the aircraft manufacturers can reduce the width of the flanges that the nut goes on, because there is less wrench diameter involved. It means he can move the bolt centerline closer to the point of stress, which has some attendant weight savings.

The engine manufacturer can move the bolts closer together and get some technical advantage. So these bring some additional weight savings beyond what are attained just by changing over to titanium as such.

Senator MALONE. As has been so well explained by the general and other witnesses, one saving leads to another.

Mr. NASON. Exactly.

Senator MALONE. If you know what material you are going to use when you make your basic design, if you know about your spacing and about the necessary attendant equipment, there is a further saving according to your testimony.

Mr. NASON. That is correct. The reason I point this out is because we feel it is inevitable that this changeover could take place in fairly short time. I think General Metzger would agree with that.

BOLTS AND NUTS

General METZGER. Senator Malone, I would like to say that the bolt and nut field is one of the most interesting fields we have for immediate application of titanium and conversion to titanium from steel. We have sponsored and financed research in those areas. We are confronted with quality problems of materials available which to this point have not been overcome, and will not be overcome until the material itself has improved in quality, and certain alloys have been provided which presently are not available in any quantity. But in this one application in the aircraft, the bolt and nut category, it will require a very substantial amount of material, and that requirement is not too far off, in my opinion.

Senator MALONE. You think from the testimony that has been offered, and of course from your prior knowledge, from investigative processes, that it will only be a matter of time that the quality of the material will suffice to go into production both in the nuts and bolts?

General METZGER. I think the quality will be available. As to the quantity at this point, I doubt it. I do not believe we can satisfy or make the transition or conversion as rapidly as perhaps the technology will permit.

Senator MALONE. General, it will take someone with your knowledge to assist the committee in adding up all of the testimony and the amount of titanium necessary in the warplanes at our present rate of production, and if we were to enter a real conflict, and also on the commercial side. The committee must of necessity lean heavily on you when we start adding up the tonnage of this material necessary which is established beyond all doubt now through the hearings in the opinion of the chairman of the committee to be far beyond any imagination apparently that the national defense services or the board of last resort, of which Mr. Flemming is chairman, and the General Services Administration, have had. We are not blaming those organizations, you understand, because they had to move slowly. This thing is apparently moving faster than anyone had any conception except someone like yourself who is right in direct touch with the investigations that have been conducted. Do you agree with that?

General METZGER. Yes, sir; I do agree.

Senator MALONE. We appreciate very much your appearance here, the first witness before our committee in Henderson, Nev., when you said 100,000 to 150,000 tons annually if the quality and quantity were available. None of us I am sure had any conception of that until the evidence started piling in. But you did have, because you are in the business. It took someone like you to jar it loose. We are very appreciative.

Does that conclude your testimony?

Mr. NASON. Yes, sir.

Senator MALONE. We appreciate very much your appearance here, Mr. Nason, and if you have any further information, will you please address it to the chairman of the committee at the Senate Office Building.

Mr. NASON. Thank you.

(The information received is as follows:)

ELASTIC STOP NUT CORP. OF AMERICA,
Union, N. J., December 7, 1953.

Hon. Senator GEORGE MALONE,
Senate Office Building, Washington, D. C.

DEAR SIR: We appreciated the opportunity to express our views on the titanium program during the recent hearings on strategic metals conducted by the Senate Committee on Interior and Insular Affairs.

We feel that the work of the subcommittee has been of great assistance to us and to the aircraft industry in clarifying the objectives toward which the industry and Government should move in the manufacture and use of titanium metal.

We felt that the testimony of Elastic Stop Nut Corporation of America would be of interest to your committee since elastic stop nuts form a common denominator for hardware items which embrace every single known aircraft application ranging from simple apparatus to the complex structures of our modern aircraft. to the best of our knowledge, there has not been a single aircraft built in this country which does not employ elastic stop nuts.

Our interest in the hearings was motivated by recent requirements placed on us by Republic Aviation Corp. and Chance Vought Division of United Aircraft Corp., manufacturers of fighter-type aircraft for the United States Air Force and the United States Navy, respectively. We find that the material requirements for these two companies will seriously tax the output of one of the major suppliers of titanium alloy. In view of this, we are placed in a somewhat difficult position with other airframe and engine companies since they too desire titanium fasteners, and we have no real basis on which to predict the future availability of the material, its price, and its potential market. It is hoped that some firm Government policy will result from the hearings conducted by your committee.

We have enclosed with this letter three copies of a testimonial brief which we believe you will want to include in your record of the committee hearings on titanium.

If Elastic Stop Nut Corp. of America can be of any further assistance to your committee, please do not hesitate to call upon us.

Very truly yours,

ELASTIC STOP NUT CORP. OF AMERICA,
E. F. NASON, *General Sales Manager.*

We have offered our services to the subcommittee because we are presently engaged in a program to manufacture self-locking nuts of titanium. We may have some data from a hardware point of view which will point up the need for new titanium capacity.

Our concern takes care of approximately 75 percent of the self-locking nut requirements of the aircraft industry. These nuts, which include a locking device to prevent loosening on the bolt during extreme vibration, are made from a variety of materials including steel, aluminum, and so forth, but approximately 90 percent, because of the loads involved, are steel.

They constitute a small but significant portion of aircraft and engine weight. We have developed with our own funds titanium counterparts of these steel nuts and are ready to supply the needs of the aircraft industry providing raw material can be made available.

The self-locking nut is a form of common denominator for all aircraft and engines. From our surveys of the industry, it appears that self-locking nuts are one item with which the industry can take immediate advantage of the weight-saving features of titanium.

As pointed out earlier, we have developed nut designs ready for manufacture which encompass the complete temperature range for practical use of titanium. Currently, three major aircraft companies, Republic, Chance Vought, and Boeing have processed inquiries for large quantities of titanium self-locking nuts. In the case of Republic, we are told they will be incorporated in the F–84–F airplane as soon as available. I might say in passing that the weight saving mentioned yesterday by Mr. O'Donnell of Republic did not include self-locking nuts.

The Republic inquiry brings out some interesting facts regarding raw material requirements. They want 400,000 nuts per month. Considering that our shop scrap would be the same as for processing steel, our monthly consumption of titanium alloy for Republic alone would be 2,200-plus pounds. Let me repeat: Republic has told us they could and would incorporate these nuts today and we haven't even determined the cost.

If the entire airframe industry proposed converting on the same basis, our titanium requirements would look something like this.

We currently process 1,200,000 pounds of steel per month in hexagon nuts alone. Again assuming the same shop scrap rate would apply for titanium, a complete changeover by the industry would result in a monthly consumption of 685,000 pounds of alloy.

Actually, insofar as titanium is concerned, we are proposing nut designs to make more economical use of the metal. A 12-point nut not only permits smaller diameter and less weight but has secondary weight saving in the airframe or engine by reducing the wrench envelope which in turn permits narrower flanges and the placing of the bolt centerline closer to the point of stress.

Taking a ¼-inch nut as an example, the 12-point nut represents a 35 percent weight saving over a hex type in the same material. This is a nut broached from bar. One-quarter inch size is used because that represents the largest volume item for structural applications. If a satisfactory heading process can be developed to convert machined parts to forged parts, we could produce an even lighter 12-point nut which would result in a 47 percent weight saving. All these figures are predicated on identical strengths to equivalent steel nuts. Similar values pertain for larger sizes. It is doubtful if titanium nuts would be used in sizes smaller than one-fourth inch except for high temperatures since high strength aluminum nuts are now available in those sizes. The program for Republic is predicated on use of aluminum up to one-fourth inch and titanium above for the present.

I wish it would have been possible to accurately convert the 1,200,000 pounds of steel used for hexagon nuts to equivalent titanium usage in its most efficient form. This cannot be done because our knowledge of processing is limited, but an estimate can be given. Starting with our equivalent, hex nut of titanium would consume 685,000 pounds of alloy per month. By reducing the hexagon type to 12-point nuts, the titanium requirement would be 480,000 pounds per month. Converting still further to the headed 12-point type, which would require a complete change over of our facilities from screw machines to headers, would lower this figure to approximately 170,000 pounds per month, or 85 tons of alloy material and 140 tons per month of titanium sponge, all other things being equal.

As you can appreciate from the foregoing testimony, we are in a rather difficult forecasting situation and we hope this hearing may establish some basis for progress. It cannot be emphasized too strongly that immediate needs for titanium are present, and, in the case of self-locking nuts, the material can be used immediately.

Chairman MALONE. We have one more witness that would like to present a statement, Mr. Mosier.

STATEMENT OF HAROLD MOSIER, AIRCRAFT INDUSTRIES ASSOCIATION, WASHINGTON, D. C.

Mr. MOSIER. My name is Harold Mosier. I represent Aircraft Industries Association, which is an organization composed of all of the aircraft manufacturing companies, the aircraft engine manufacturing companies, and the large parts manufacturing companies.

Admiral DeWitt C. Ramsey (Retired) is the president of the association, and he was asked to testify, but it was impossible for him to be present. He has, however, prepared a statement which I present and ask that it be made a part of the record.

Senator MALONE. It will be accepted at this point, Mr. Mosier, as a part of your presentation, as a statement by Admiral DeWitt C. Ramsey (Retired).

(The statement is as follows:)

The aircraft industries' interest in titanium stems from the metal's high strength, light weight, high endurance or fatigue limit, and corrosion and heat resistance.

In order to focus the attention of the titanium producer and those Government agencies responsible for the development of the titanium industry on the real needs of the airframe industry, the AIA's aircraft research and testing committee initiated a survey in August 1952 of the members of the Aircraft Industries Association. The purposes of this survey were:

1. To obtain an industrywide estimate of required sizes and forms of titanium products;

2. To obtain an approximate idea of strength and fabrication requirements for both present and future design; and

3. To obtain an estimate of how much titanium could be utilized per individual airframe in both the reasonably near future and distant future.

The results of this AIA committee survey are noted in the enclosed report which was disseminated earlier this year to the armed services and to the titanium producers to indicate the extent of titanium production facilities needed and the types and strength of titanium alloys which should be developed for airframe usage.

Commercially pure titanium is being used in increasing quantities in sheet form for replacement of stainless steel in hot areas surrounding the engines. These applications, which are nonstructural, could amount to about 2 percent of the airframe weight at present, with an increase to about 3.5 percent for future designs.

The great usage potential for titanium in aircraft is in the form of high-strength alloy sheet, forging, bar, plate, extrusion, tubing, and high strength fasteners, i. e., structural applications. Aircraft and missile designs now on the board will require a higher heat resistant surface metal than aluminum and the industry is looking toward improved titanium alloys for this purpose. Present titanium alloy usage of 3 percent of the airframe weight is expected to increase to about 30 percent for future designs.

Alloys of titanium have suffered from the following difficulties as noted in the attached report: (*a*) Low minimum guaranteed strength of present commercially available alloys; (*b*) limited availability; (*c*) poor quality; (*d*) nonweldability; and (*e*) high cost.

Attendant with the use of any new material are the usual difficulties of fabricating practices, machining and forming production techniques and service life determination. The machinability characteristics of titanium have received preliminary investigation by a number of our member companies.

A word of caution on the increased usage of titanium might be in order. Unless and until titanium sponge production reaches a capacity that would sustain a reasonable mobilization effort, its use should be limited to that where engineering redesign (of airplanes and missiles) for substitute materials would not be required. Our engine production during the last war suffered from a similar situation involving critical minerals in short supply.

(The Aircraft Industries Association summary report is as follows:)

AIRFRAME INDUSTRY TITANIUM USAGE REQUIREMENTS—SUMMARY REPORT
MAY 1, 1953

Prepared by Aircraft Research and Testing Committee, Aircraft Industries Association, Washington, D. C.

PART I. INTRODUCTION

Foreword

The welter of optimistic articles, reports, and general information on titanium being published in current literature is such as to obscure the real requirements of the airframe industry, one of the few industries which can justifiably employ titanium at the present time, with respect to titanium. In order to focus the attention of the titanium producers and those agencies responsible for the development of the titanium industry on the real needs of the airframe industry, an aircraft research and testing committee questionnaire, ARTC–WR–52–63, dated August 6, 1952, under the sponsorship of Boeing Airplane Co. as project W–67, was issued to the members of the Aircraft Industries Association of America.

The summary of the replies to this questionnaire is contained herein.

Purpose

The purpose of project W–67 was to obtain an industrywide estimate of required sizes and forms of titanium products, an approximate idea of strength and fabrication requirements for both present and future design, and an estimate of how much titanium could be utilized per individual airframe in both the near future and reasonably distant future. It was highly desired that this information be disseminated to the armed services and to the titanium producers as a consensus of aircraft industry opinion on titanium requirements. This information should aid in determining the extent of titanium production facilities needed and the types and strength of titanium alloys which should be developed for airframe usage.

PART II

Discussion of data

The replies to project W–67 questionnaire on titanium-usage requirements by the aircraft industry are summarized here in tables I and II. Specific items of broad interest, all included in tables I and II, such as sizes and gages, minimum required properties, and quantity required in terms of airframe weight are presented separately in figures 1 through 8 to enable clear evaluation.

It is desirable to separate titanium products into two groups:

(*a*) Commercially pure titanium (to be subsequently designated as C. P. titanium).

(*b*) Titanium alloys.

All of the data to be subsequently discussed are included in tables I and II and broken down in further detail in figures 1 through 8.

A. C. P. titanium

The aircraft industry has immediate use and it is utilizing in production aircraft C. P. titanium, principally in the form of sheet. The typical usage is limited to nonstructural items replacing annealed stainless steels and in fewer cases work-hardened stainless steel and alloy steels heat-treated to low strength ranges. There is apparently a very small usage potential for C. P. titanium in the form of forgings, bar, plate, and extrusions. A slight usage exists for hydraulic tubing of C. P. titanium and possibly for rivets. However, by far the greatest usage of C. P. titanium now and in the future will be in the form of sheet.

The industrywide average quantities of C. P. titanium which could be utilized in present design in terms of airframe weight is 2 percent, figure 8. In future design the industrywide average utilization is 3.5 percent. Assuming an annual procurement program of 100 million pounds of airframe weight, the minimum quantities of C. P. titanium that would be required on the basis of this survey are 2 million pounds for present and 3,500,000 pounds for future design, respectively. These values are finished weights only. An additional quantity of 25 to 30 percent of finished weights will be required for spare parts and scrap produced during fabrication.

Minimum sheet gages, figure 1, vary from 0.008 to 0.032 inch and the average industry requirement is 0.016 inch. Sizes and tolerances equivalent to stainless steel values are generally satisfactory. The minimum desired tensile strength ranges from 75,000 to 124,000 pounds per square inch and averages approximately at 80,000 pounds per square inch, figure 4.

In general, C. P. titanium is being supplied under acceptable specifications although some of the sheet material is being received in conditions at variance with the specifications. The aircraft industry as a whole appears to be able to design, procure and fabricate (form, weld, and rivet) aircraft components of C. P. titanium without encountering insurmountable difficulties.

B. Titanium alloys

1. Usage quantities.—The great usage potential for titanium in aircraft fabrication is in the form of high strength alloy sheet, forging, bar, plate, extrusion, and tubing. Appreciable usage exists for high strength fasteners. In figure 8 if the present and future C. P. titanium percentages of airframe weight are subtracted from the overall figures of 5 percent for present and 35 percent for future requirements, titanium alloys will constitute from 3 percent of airframe weight in present design to roughly 30 percent in future designs. Based on 100 million pounds of airframe weight, a minimum quantity of 3 million and 30 million pounds finished weight of alloys would be required, respectively. This 100 million pound figure is exclusive of missile weights. Again, an additional amount, 25 to 30 percent of finished weights, will be required for spares and scrap. It

appears obvious that a considerable reduction in the price of titanium will be required before it would be economically feasible to use this amount of titanium products.

2. *Present usage limitation.*—There are several reasons for the low present and near future requirements given for titanium alloys. These are, in the main, as follows:

(*a*) Low minimum guaranteed strength of present commercially available alloys.

120,000 pounds per square inch for sheet.
140,000 pounds per square inch for forging, bar, and plate.

These low strengths do not permit a gage for gage or size for size substitution for present higher density aircraft material except for annealed stainless steel components for which CP titanium is normally adequate. For subsonic and much of supersonic design the present alloy sheet can only be substituted for one-fourth and one-half hard stainless steel to obtain appreciable weight savings. No weight saving (based only on equivalent strength weight ratio) is obtained from the present forging, bar, or plate alloys over alloy steels heat-treated to 230,000 pounds per square inch. There are prospects of using alloy steels at strengths of 280,000 pounds per square inch. Omitting the additional important factor of critical buckling, the present alloys are not as strong as the available aluminum alloys when compared on their equivalent minimum guaranteed strength-weight ratios.

(*b*) Limited availability: The availability status of the present alloys is uncertain. There has been considerable history of unfilled orders and excessive delivery schedules. The status of present alloys are uncertain in that they have and may be withdrawn from production at any time.

(*c*) Poor quality: Much of the materials received by the aircraft industry has been of poor quality, being either deficient or too variable in properties within individual sheets or bars and from sheet to sheet.

(*d*) Nonweldability: Much of the present usage envisaged, tanks (for missiles), ducts, and airframe components requires either resistance or fusion welding. None of the present alloys can be considered as being satisfactorily weldable by either process.

(*e*) High cost of present products: The importance of this item has not been determined.

3. *Desired strengths for future usage.*—Desired strengths of alloys for each company reporting are given in figures 5, 6, and 7. The average industrywide requirements of minimum tensile strengths are 160,000 pounds per square inch for sheet, 166,000 pounds per square inch for extrusions, and 170,000 pounds per square inch for forging, bar, and plate. Data on desired elevated temperature strengths are also indicated and vary widely both as to strengths as well as to service temperatures.

Apparently two philosophies govern the individual elevated temperature strength requirements for future usage (beyond 1955) as indicated in this survey.

(*a*) Some companies have indicated elevated temperature strengths of such values as can be reasonably expected, judging from present alloys, of alloys having requisite high room temperature strengths.

(*b*) Other companies have submitted elevated temperature strength requirements that appear unreasonably high judging from the above criteria but which are based on what is desirable rather than what may be feasible. The alloys having the desired elevated temperature strength are not necessarily the same alloys having the required room temperature strengths. It may not be unreasonable to assume that alloys can be developed which will not show the marked decrease in properties with temperature occurring in the present alloys. In one instance the values submitted are those which enable the performance of titanium alloys at elevated temperatures to equal the performance of aluminum and steel alloys at present service temperatures.

4. *Desired sizes and forms.*—All forms of titanium alloys are required, sheet, forgings, extrusions, tubing, plate and bar. Average minimum gage of sheet is .016 inch. Average maximum weight of forgings or machined parts is 2,000 pounds. Tubing sizes range from a minimum O. D. of ¼ inch to an overall maximum of 6 inches with a minimum wall thickness beginning with 0.025 inch. Detail requirements as to extrusion sizes were not submitted in most replies but it is safe to assume that titanium alloy extrusions in sizes and forms that approach those of present aluminum alloy extrusions will be required.

5. Other requirements.—Formability requirements vary from part to part which renders difficult any general formability criteria. For wing skins very slight formability is needed whereas for ducts a high degree of formability is necessary. It might be indicated that titanium alloys should at least be as formable when subjected to hot forming practice as present alloys, which will be replaced, are at their standard forming temperatures.

The greatest potential future usage of titanium alloys in the aircraft industry is in structural applications where welding is not necessarily a practical or a critical consideration since mechanical fastening methods have been or may be satisfactory such as in riveted structures or bolted connections. However, further design refinements may be necessary in supersonic design which might eliminate the usage of rivets or unfilled joints in aircraft components exposed to the slip stream. Resistance welding of structural sheet components appears more important now that fusion weldability judging from present usage of 24S and 75S aluminum alloys so that the latter should not be considered mandatory.

In certain types of applications such as missile tanks which serve both as load carrying structures and corrosive propellant containers, there is an immediate usage potential for an intermediate strength alloy with an estimated minimum tensile strength of 120,000 p. s. i., a strength versus temperature relationship similar to 17-7pH or low alloy steel, and which is fusion weldable. Its corrosion resistance to white or red fuming nitric acid should not be greatly inferior to C. P. titanium.

Usage of titanium alloys in sandwich construction will entail additional requirements not indicated herein.

Air Force survey

Mention should be made of the USAF Titanium Conference held at Headquarters, Air Materiel Command, on March 9–10, 1953, in which the problems of quality, quantity, availability, and requirements were thoroughly discussed between governmental services, titanium producers, and airframe and engine manufacturers. The major conclusion drawn from this meeting is that for the next several years there will be insufficient titanium to supply the airframe and engine requirements.

The sponsor recommends that future surveys on airframe titanium usage requirements be consolidated with the Aircraft Production and Resources Agency survey which is being conducted on a recurrent basis. It is also recommended that the latter survey be amplified to include the airframe industry requirements as to strength, fabricating characteristics, and forms for the purpose of guiding industrial and governmental research and developmental programs on titanium alloys. It appears unrealistic to indicate how much titanium is required without at the same time explaining the basis on which the quantity is determined.

Conclusions

1. Present and near future C. P. titanium usage amounts to 2 percent of airframe weight. Future usage will average 3.5 percent of airframe weight.
2. C. P. titanium will be used principally in the form of sheet.
3. Present and near future titanium alloy usage amounts to 3 percent of airframe weight. Future usage averages 30 percent of airframe weight.
4. Titanium alloys will be used in all the available forms, sheet, forgings, extrusions, etc.
5. Gages, sizes and tolerances of C. P. and alloy titanium should be at least similar to those now applying to stainless steels. Weights of forgings up to 2,000 pounds are contemplated and plate requirements up to 9,000 pounds have been indicated.
6. Minimum desired strengths of 160,000 p. s. i. for sheet, 165,000 p. s. i. for extrusions, and 170,000 p. s. i. for forgings, bar and plate are required for future usage.
7. Elevated temperature strength requirements are dependent on individual design requirements.
8. In general, every process now applicable to present structural materials (magnesium alloys, aluminum alloys, stainless steel, and low alloy steels) should be applicable to titanium alloys.

Recommendations

The data herein included should be distributed to the armed services, governmental and private research agencies, and to the titanium producers for the

SUMMARY OF TABLE I REPLIES (PAGE 1)

PRESENT AND NEAR FUTURE USAGE REQUIREMENTS OF TITANIUM AND TITANIUM ALLOYS (1952 - 1955)

COMPANY	MATL.	FORM	GAGES & SIZES	TYPE OF APPLICATION	MINIMUM GUARANTEED MATERIAL PROPERTIES — ROOM TEMPERATURE				ELEVATED TEMPERATURES						OTHER REQUIREMENTS — FORMABILITY	WELDABILITY		HEAT TREAT	OTHER	MAGNITUDE OF USAGE	SIGN. OF USAGE
					U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	OTHER	TEMP. °F	TIME TEMP HRS	U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE / OTHER	BEND RADIUS	FUSION	SPOTWELD			% AIRFRAME WEIGHT	
Northrop	C.P. Ti	Sheet	.020 - .125	Non-Struct.	75-80	65-70	20		RT-450	4	70	60	25		3T	No	Yes	No			
	Ti Alloy	"	"	Struct.	150-180	120-160	10-15		RT-800	4	130-160	100-140	10-12		3T-5T	Yes & No	Yes	No			
	"	Forging	Varied	"	180	160	5		600	4	160	140	5			No	No	Yes		1.5	
	"	Bar	.125 - 2" Dia.	Struct. & Bolts	130-180	105-150	15-8		RT-600	4	150	125	8			Yes & No	No	Yes & No			
	"	Extru.			130	105	15									Yes	No	No			
																			Total	1.5%	
Vought	C.P. Ti	Sheet	.012 - .032	Non-Struct.	125-150	-	-		-	-	-				Good			No	Good	1.0	
	Ti Alloy	Forging	to 6x12x20															No	Machin.	5.0	
		Extru. T's & L's to 2-1/2x2-1/2x1/4																No		2.0	
																			Total	8.0%	
North American	C.P. Ti	Sheet	.016 - .090	Non-Struct.	80	70	15		600		35	25		f	3T	No	Yes	No		1.0	High
	Ti Alloy	Sheet	.025 - .125	Struct.	120	110	10		600		85	65			3T	No	No	No		5.5	High
	"	Bar	to 1.5" Dia. or thk'r.	"	140	130	10		600		85	65				No	No	No		1.0	High
	"	Forging																	Total	9.5%	
Lockheed	C.P. Ti	Sheet	.016 - .081	Non-Struct.	75 Max -80	60 Max -70	25-15		RT-600	1000	45	35	15		2T-3.5T	Desired	Yes	-		6.0	High
	Ti Alloy	"	"	Struct.	125	115	15		600	1000	80	65	15		3.5T-6T	"	Yes	-		0.5	High
																			Total	6.5%	
Bell	C.P. Ti	Sheet	.015 - .125	Non-Struct.	80	65	18 Min		700	500	55	40	18 Min		Deep Draw	Desired	Yes	-	Stiffeners annealed	1.0	Moderate
	Ti Alloy	Forging Bar-Rod	to 70 lbs.	Struct.	165	150	10 Min									"		Accept.	Good machin.	.5	"
																			Total	1.5%	
Martin	Ti Alloy	Sheet	.016 - .080	Struct. & Non-Struct.	100-150	75-130	20-10		300-800	10-10000	60-125	40-100	20-10		Moderate	Yes & No	Yes & No	Yes & No		2.0	Normal
	"	Bar	to 4x5x150"		150	130	10		400	10000	100	70	10		-	No	No	Yes	Mach.	1.0	
																			Total	3.0%	

Cch.					TABLE I
Tec					PRESENT TITANIUM USAGE REQUIREMENTS
Chk					BOEING AIRPLANE COMPANY
Appr.					SEATTLE 14, WASHINGTON
Appr.					

DATA SHEET

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SUMMARY OF TABLE I REPLIES (PAGE 1)

RE USAGE REQUIREMENTS OF TITANIUM AND TITANIUM ALLOYS (1952 - 1955)

GUARANTEED MATERIAL PROPERTIES								OTHER REQUIREMENTS					MAGNITUDE OF USAGE	SIGN. OF USAGE	REMARKS
	ELEVATED TEMPERATURES							FORM-ABILITY	WELDABILITY		HEAT TREAT	OTHER			
THER	TEMP. °F	TIME TEMP HRS	U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOTWELD			% AIRFRAME WEIGHT		
	RT-450	4	70	60	25			3T	No	Yes	No				When satisfactory alloys & extrusions
	RT-800	4	130-160	100-140	10-12			3T-5T	Yes & No	Yes	No				are available.
	600	4	160	140	5				No	No	Yes		1.5		Titanium usage will increase more when
	RT-600	4	150	125	8				Yes & No	No	Yes & No				suitable alloys become available.
									Yes	No	No				
												Total	1.5%		
								Good			No	Good	1.0		Usage can result in saving in
	-	-	-								No	Machin.	5.0		airframe weight of 4%.
											No		2.0		
												Total	8.0%		
	600		35	25		f		3T	No	Yes	No		3.0	High	Potential usage of tubing.
	600		85	65				3T	No	No	No		5.5	High	Approx. Increase in Aircraft Part.
	600		85	65					No	No	No		1.0	High	Merits the use of titanium.
												Total	9.5%		
	RT-600	1000	45	35	15			2T-3.5T	Desired	Yes	-		6.0	High	Models A, B, C, D, & E.
	600	1000	80	65	15			3.5T-6T	"	Yes	-		0.5	High	
												Total	6.5%		
	700	500	55	40	18 Min			Deep Draw	Desired	Yes	-	Withstand anneals	1.0	Moderate	
									"		Accept.	Good machin.	.5	"	
												Total	1.5%		
	300-800	10-10000	60-125	40-100	20-10			Moderate	Yes & No	Yes & No	Yes & No		2.0	Normal	Firewalls, Shrouding, Flat Plates,
	400	10000	100	70	10			-	No	No	Yes	Mach.	1.0		Tube, Miscellaneous Fittings.
												Total	3.0%		

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SUMMARY OF TABLE I REPLIES (PAGE 2)

PRESENT AND NEAR FUTURE USAGE REQUIREMENTS OF TITANIUM AND TITANIUM ALLOYS (1952 - 1955)

COMPANY	MATL.	FORM	GAGES & SIZES	TYPE OF APPLICATION	MINIMUM GUARANTEED MATERIAL PROPERTIES — ROOM TEMPERATURE				ELEVATED TEMPERATURE							OTHER REQUIREMENTS					MAGNITUDE OF USAGE	SIGNIFICANCE OF USAGE
					U.T.S.	T.Y.S.	ELONG.	OTHER	TEMP.	TIME TEMP.	U.T.S.	Y.S.	ELONG.	STRESS RUPTURE	OTHER	FORMABILITY	WELDABILITY		HEAT TREAT	OTHER	% AIRFRAME WEIGHT	
					KSI	KSI	% IN 2".		°F	HRS	KSI	KSI	% IN 2"			BEND RADIUS	FUSION	SPOTWELD				
Boeing (Seattle)	C.P. Ti	Sheet	.016 - .125	Non-Struct.	75	60	15		RT-2000	1000-.25	-	-	-	-	-	1T	Yes	Yes	Arm.		1.0	Mt-Sav.
	Ti Alloy	"	"	Struct.	120-150	110-130	15-12		RT-1000	1000	100-110	80-100	15		Creep Resist.	1T	Desired	Desired	"		1.5	"
	"	Forging	to 1000 lbs.	"	150-160	130-150	12-8		RT-1000	1000	110	-100	8		"	—	Yes & No	-	"		7.0	"
	"	Plate & Bar	to 500 lbs.	"	150	130	12		-	-	-	-	-		-	—	Yes	-	"		1.0	"
	"	Fasteners	-	"	160	150	8		-	-	-	-	-		-	—	-	-	-		1.0	"
																				Total	11.5	
Fairchild	C.P. Ti	Sheet	.016 - .025	Non-Struct.	70	Normal →										Mild	No	Yes	No		1.0	Moderate
	Ti Alloy	"	.060 - .090	"	90	" →										Good	Yes	Yes	No		Negl.	"
	"	Tubing	.025-.065 2-3/4 to 17/4	"	90	" →									(Fatigue Resist.	Critical	Yes & No	No	No		1.0	"
	"	Forging	to 10x10x100"	Struct.	160	130	12		No Requirement					Good		Forgeability	Flash-w.	No	Yes		9.0	High.
																				Total	11.0%	
Boeing (Wichita)	C.P. Ti	Sheet	.025 - .062	Non-Struct.	75	60	15									Excell.		Yes			1.0	Moderate
	Ti Alloy	"	.016 - .020	Struct.	125	75	15		RT-600		60					"	Yes	Yes	Yes		1.0	"
																				Total	2.0%	
Piasecki	C.P. Ti	Sheet		Non-Struct.	80	60	20	Impact 15 ft/lb								Joggling Bending Stretch	Desired	Yes		(1,065 lbs 1952)		High
	"	Tubing		Struct.	80	60	20	"								"	"			(422 lbs 1953)		"
	"	Forging		"	80	60	20	"									"			(10,510 lbs 1954)		"
	"	Extrusion		"	80	60	20	"								"	"	"		(65,800 lbs 1955)		"
	Ti Alloy	Tubing		"	150	130	10	"									"		Total	77,727 lbs.		"
	"	Forging		"	120	105	15	"									"					"
Douglas	C.P. Ti	Sheet	.016 - .050	Non-Struct.	80	70	15									Bend Stretch	None	None			2.5	Eng. Mt-Sav.
	Ti Alloy	Forging	3x6x28"	Ldg. Gear Mech. Lever	130	120	10		Ambient							None	"	"	Yes	(2 parts/ship 102 avg.		Mt-Sav.
																				Total 2.5%		

Calc.					
Test				TABLE I -	
Engr.				PRESENT TITANIUM USAGE REQUIREMENTS	
Appr.				BOEING AIRPLANE COMPANY	
Appr.				SEATTLE 14, WASHINGTON	

DATA SHEET

BAC 3000 A-R3

SUMMARY OF TABLE I REPLIES (PAGE 2)

E REQUIREMENTS OF TITANIUM AND TITANIUM ALLOYS (1952 - 1955)

MATERIAL PROPERTIES — ELEVATED TEMPERATURE							OTHER REQUIREMENTS						MAGNITUDE OF USAGE	SIGNIFICANCE OF USAGE	REMARKS
							FORMABILITY	WELDABILITY		HEAT TREAT	OTHER				
TEMP. °F	TIME TEMP. HRS	U.T.S. KSI	Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOTWELD				% AIRFRAME WEIGHT		
RT-2000	1000-.25	-	-	-	-	-	3T	Yes	Yes	Ann.			1.0	Wt-Sav.	Usage - Firewalls, Fairings, Cowling
RT-1000	1000	100-110	80-100	15		Creep Resist.	3T	Desired	Desired	"			1.5	"	Nacelle Structure - Ducts.
RT-1000	1000	110	-100	8		"	—	Yes & No	-	"			7.0	"	Wing Empennage, Landing Gear.
-	-	-	-	-		-	—	Yes	-	"			1.0	"	Body Bulkheads.
-	-	-	-	-		-	—	-	-	-			1.0	"	Shear Bolts Rivets, etc.
												Total	11.5		
							Mild	No	Yes	No			1.0	Moderate	Immediate Usage on Cargo Transport
							Good	Yes	Yes	No			Mag.	"	Development Items on Cargo Transport.
						(Fatigue, Resist.	Critical	Yes & No	No	No			1.0	"	
No Requirement					Good		Forgability	Flash-w.	No	Yes			9.0	Sign.	Development Items on Cargo Transport.
												Total	11.0%		
							Excell.		Yes				1.0	Moderate	Expect Prod. Inquire. by Mid 1953.
RT-600		60					"	Yes	Yes	Yes			1.0	"	Excellent weldability required.
												Total	2.0%		Should be spotweldable to C.P. Titanium
							Joggling Bending Stretch	Desired	Yes			(1,065 lbs 1952)		High	Titanium Rivets Desirable.
							"	"				(422 lbs 1953)		"	Flashwelding Desirable.
								"				(10,510 lbs 1954)		"	C.P. Sheet - Engine Cowling Shroud, Firewall.
							"	"	"			(65,800 lbs 1955)		"	C.P. Ext. - Engine Comp. Frames
								"			Total	77,797 lbs.		"	C.P. Ext. - Forging & Tubing - Longerons
								"						"	Ti Alloy Forging Landing Gear
															and Tubing - Engine Mounts.
							Bend Stretch	None	None				2.5	Imp. Wt-Sav.	Firewalls & Nacelles, Wing Mkhd. Firew
Ambient							None	"	"	Yes		(2 parts/ship 10)	avg.	Wt-Sav.	
													Total 2.5%		

SHEET

SUMMARY OF TABLE I (PAGE 3)

PRESENT AND NEAR FUTURE USAGE REQUIREMENTS OF TITANIUM AND TITANIUM ALLOYS (1952 - 1955)

COMPANY	MATL.	FORM	GAGES & SIZES	TYPE OF APPLICATION	MINIMUM GUARANTEED MATERIAL PROPERTIES — ROOM TEMPERATURE				ELEVATED TEMPERATURES							OTHER REQUIREMENTS					MAGNITUDE OF USAGE	SIGNIFICANCE OF USAGE
					U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	OTHER	TEMP. °F	TIME TEMP HRS.	U.T.S. KSI	T.Y.S. KSI	ELONG % IN 2"	STRESS RUPTURE	OTHER	FORMABILITY BEND RADIUS	WELDABILITY FUSION	WELDABILITY SPOTWELD	HEAT TREAT	OTHER	% AIRFRAME WEIGHT	
Convair (Ft. Worth)	C.P. Ti	Foil	3 ft. wide	Blankets	-				2750	Indef.												
	"	Sheet	.008-.020 4'x8'	Non-Struct.	80-75	70-60	25-20		100-1000	Indef.	20	12-15	25-15			Draw Brake	Yes & No	Yes	Yes		.5	Wt.-Sav. Insul.
	Ti Alloy	"	.040-.375 4'x8'	Struct.	130-170	120-140	12-10		600-1000	10-Indef.	30-70	20-55	30-15			Slight Medium	"	Yes & No	Yes & No		.5	Fct.-Sav.
	"	Plate	.250-16" x 150" 2x5"	Struct.	180	140	8		160°	Indef.	170	130	12			Medium						"
	"	Bar & Rod	1/4 to 3" Dia	Struct.	125-180	100-140	17-10		100-1000	2-Indef.	30-170	20-130	20-12				Yes & No	No	Yes & No	Mach.	1.50	Wt.-Sav.
	"	Forging	Variable 24"x10" 12"x12"	Struct.	125-200	100-165	12-10		100-1700	2-Indef.	60-170	40-130	15-10				"		"	"	.50	"
	"	Extrus.	1-1/4x1-1/4x5" 3"x2"-28"	Struct.	130-170	120-140	10		260-600	2-Indef.	90-140	80-120	15			None to small				"	Negl.	"
	"	Tubing	1/4 to 4" Dia.	Str. & Non-Str.	100-180	80-140	12-10		100-1000	2-Indef.	30-170	20-130	15-12			None to Excel.	Yes		Yes	"	Negl.	"
																				Total	3.0%	
Convair (San Diego)	C.P. Ti	Sheet	.016 - .064	Str. & Non-Str.												Stretch Form Hydrop.	Yes & No	Yes & No			1,795*	Lb. Req.
	Ti Alloy	"	.020 - .040	"													No	"			14,020	Lb. Req.
																						Pipes,
																					24,610	Lb. Req. walls,
																				Total	62,385	Lbs.
Republic	C.P. Ti	Sheet	.01 - .125		80	70	15		400-1000	12 max.	45	25	25			High	-	-	-	-	0.5	Moderate
	"	Plate	.625		80	70	15		-	-	-					Moderate	-	-	-	-		
	"	Rod	1-2		80	70	15		-	-	-					Moderate	-	-	-	-		
																				Total	0.5%	

Cal.			APPROVED	DATE
Tec.				
Chk.				
Appr.				
Appr.				

TABLE I -
PRESENT TITANIUM USAGE REQUIREMENTS

BOEING AIRPLANE COMPANY
SEATTLE 14, WASHINGTON

DATA SHEET

BAC 200 A-200

* Includes 100% Scrappage, Lear

SUMMARY OF TABLE I (PAGE 3)

TURE USAGE REQUIREMENTS OF TITANIUM AND TITANIUM ALLOYS (1952 - 1955)

GUARANTEED MATERIAL PROPERTIES								OTHER REQUIREMENTS					MAGNITUDE OF USAGE	SIGNIFICANCE OF USAGE	REMARKS
	ELEVATED TEMPERATURES							FORMABILITY	WELDABILITY		HEAT TREAT	OTHER			
THER	TEMP. °F	TIME TEMP HRS.	U.T.S. KSI	T.Y.S. KSI	ELONG % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOTWELD			% AIRFRAME WEIGHT		
	2750	Indef.													
	200-1000	Indef.	20	12-15	25-15			Draw Brake	Yes & No	Yes	Yes		.5	Wt.-Sav. Mod.	Fairing, Skin & Firewall, Ducting
	600-1000	10-Indef.	30-70	20-55	30-15			Slight Medium	"	Yes & No	Yes & No		.5	Wgt.-Sav.	Dowling, Nac. Struc. Skin, Fairings
	160°	Indef.	170	130	12			Medium						"	Skin Splice
	200-1000	2-Indef.	30-170	20-130	20-12				Yes & No	No	Yes & No	Mach.	1.50	Wt-Sav.	Fasteners, Engine Fittings.
	200-1700	2-Indef.	60-170	40-130	15-10				"		"	"	.50	"	Fittings, Structural
	260-600	2-Indef.	90-140	80-120	15			None to small				"	Neg.	"	Spar Caps, Structural.
	200-1000	2-Indef.	30-170	20-130	15-12			None to Excel.	Yes		Yes	"	Neg.	"	Hyd. & Pneum. System, Ducts, Truss Ass. Seat Posts
												Total	3.0%		
								Stretch Care Hydrop.	Yes & No No	Yes & No "			3,755	Lb. Required in 1952 Nacelle, Fus. Wing Struc.	
													14,020	Lb. Required in 1953 Engine Shrouding, Tail, Pipes, Lead. Edges.	
													24,610	Lb. Required in 1954 Fittings, Flooring, Firewalls, Hikhds.	
												Total	62,385	Lbs.	
	-	-	-												
	400-1000	12 max.	45	25	25			High	-	-	-	-	0.5	Moderate	Uses: Tail Pipe Shroud, Ammo Boxes, Fuselage Ejector.
	-	-	-					Moderate	-	-	-	-			
	-	-	-					Moderate	-	-	-	-			
												Total	0.5%		

* Includes 100% Scrappage, Learning & Net. Airframe Weight.

DATA SHEET

SUMMARY OF TABLE II REPLIES (PAGE 1)

FUTURE USAGE REQUIREMENTS FOR TITANIUM AND TITANIUM ALLOYS (BEYOND 1955)

COMPANY	MATL.	FORM	GAGES & SIZES	TYPE OF APPLICATION	MINIMUM GUARANTEED MATERIAL PROPERTIES											OTHER REQUIREMENTS					MAGNI. OF USAGE	SIGNIFICANCE OF USAGE
					ROOM TEMPERATURE				ELEVATED TEMPERATURE							FORMABILITY	WELDABILITY		HEAT-TREAT	OTHER	% AIRFRAME WEIGHT	
					U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	OTHER	TEMP. °F	TIME TEMP. HRS.	U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOTWELD				
Northrop	Ti Alloy	Sheet	.016 & over	str. & non-str.	175	150	20		1000	6+	160	140	25			3T	Yes	Yes	No			
	"	Rod	.125 & over	Bolts & Nuts	200	180	15		1000	6+	180	160	20				No	No	Yes			
	"	Forging	Varied	Struct.	175	160	10		1000	6+	160	150	15				Yes	Yes	Yes			
	"	Bars	"	"	180	160	15		1000	6+	165	150	20				Yes	No	Yes			
Hughes	C.P. Ti	Sheet	.032-.125	Heat-Resistant	100	80	25		400	10,000	80	60	25			Good						Highly
	Ti Alloy	"	"	Struct.	150	130	20		400	10,000	125	100	25			"		Yes		High Fatigue	10.0	"
	"	Extru.	.050-.188	"	150	130	20		400	10,000	125	100	25			Fair				"		"
	"	Bar-Rod	-	"	150	130	20		400	10,000	125	100	25			"	Yes			"		"
																				Total	10.0%	
Sikorsky	(Submitted data included in summary of Table I replies.)																					
North American	C.P. Ti	Sheet	.016-.125	Non-Struct.	80	70	15		300-800		30	20				3T	Yes	Yes	No		5.0	High
	"	Tubing	to 2.0" dia.	Hydr.Heat & Vent	80	70	15		300		55	40				3T	No	NO	No		1.0	Moderate
	Ti Alloy	Sheet	.016-.250	Struct.	180	150	15		300-800		100-150	75-120					Yes	Yes	Yes		55.0	High
	"	Bar & Forging	to 6" dia. & thk'r.	"	180	150	10		300		160	120					Yes	Yes	Yes		8.0	"
																				Total	69.0%	
Lockheed	C.P. Ti	Sheet	.016-.125	Non-Struct.	~~75 Max.~~ -80	~~60 Max.~~ -70	25-15		RT 600	1000	45	35	15			2-5T	Desired	Yes			12.0	Ballistic
	Ti Alloy	"	.020-.125	Struct.	150	130	15		600	1000	90	70	15			Good	"	Yes	Desired		16.5*	"
	"	Bar & Forging	to 700 lbs.	"	175	150	15		600	1000	110	90	15			—	Yes	Desired	"	MIF machin.	1.00	Column
																				Total	31.5%	
Ba	C.P. Ti	Sheet	.015-.125	Non-Struct.	80	65	18 Min.		700	5-500	55	40	18 Min.			Deep Draw	Yes	Yes	-		5.0	Mi-Sav.
	Ti Alloy	Plate & Sheet	.015-.250	Struct.	165	150	10 Min.		700	5-500	135	120	10 Min.			"	Desired	"	Accept.		20.0	"
	"	Bar-Rod &Forging	100 lbs.	"	165	150	10 Min.		700	5-500	135	120	10 Min.			-	Yes		"	Readily Machin.	7.0	"
																				Total	32.0%	

Calc.			REVISED	DATE
Trac				
Chk				
Appr				
Appr				

TABLE II -

FUTURE TITANIUM USAGE REQUIREMENTS

BOEING AIRPLANE COMPANY

SEATTLE 14, WASHINGTON

DATA SHEET

BAC 3400 A-822

* This weight also includes C.P. Ti pl

ART OF TABLE II REPLIES (PAGE 1)

FUTURE USAGE REQUIREMENTS FOR TITANIUM AND TITANIUM ALLOYS (BEYOND 1955)

GUARANTEED MATERIAL PROPERTIES								OTHER REQUIREMENTS					MAGNI. OF USAGE	SIGNIFICANCE OF USAGE	REMARKS
ELEVATED TEMPERATURE								FORMABILITY	WELDABILITY		HEAT-TREAT	OTHER	% AIRFRAME WEIGHT		
OTHER	TEMP. °F	TIME TEMP. HRS.	U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOT WELD					
	1000	6+	160	140	25			3T	Yes	Yes	No				When satisfactory alloys are developed,
	1000	6+	180	160	20				No	No	Yes				" " " " "
	1000	6+	160	150	15				Yes	Yes	Yes				" " " " "
	1000	6+	165	150	20				Yes	No	Yes				" " " " "
	400	10,000	80	60	25			Good						Highly	
	400	10,000	125	100	25			"		Yes		High Fatigue	10.0	"	
	400	10,000	125	100	25			Fair				"		"	
	400	10,000	125	100	25			"	Yes			"		"	
												Total	10.00%		
	300-800		30	20				3T	Yes	Yes	No		5.0	High	Applic. Rear Engine & Tailpipe.
	300		55	40				3T	No	No	No		1.0	Moderate	Possibility for use instead of st.st.
	300-800		100-150	75-120					Yes	Yes	Yes		55.0	High	Service Temp. too high for alum. alloys
	300		160	120					Yes	Yes	Yes		8.0	"	" " " " " " "
												Total	69.00%		
	RT 600	1000	45	35	15			2-5T	Desired	Yes			12.0	Ballistic	Prop required also.
	600	1000	90	70	15			Good	"	Yes	Desired		16.5*	"	" " " ; comp. in buckling.
	600	1000	110	90	15			—	Yes	Desired	"	Fair machin.	1.00	Column	Buck. better than 4 to 75S-T6.
												Total	31.5%		
	700	5-500	55	40	18 Min.			Deep Draw	Yes	Yes	-		5.0	Wt-Sav.	Vitally needed.
	700	5-500	135	120	10 Min.			"	Desired	"	Accept.		20.0	"	" "
	700	5-500	135	120	10 Min.			-	Yes		"	Readily machin.	7.0	"	" "
												Total	32.0%		

* This weight also includes C.P. Ti plate used for armour.

DATA SHEET

SUMMARY OF TABLE II REPLIES (PAGE 2)
FUTURE USAGE REQUIREMENTS FOR TITANIUM AND TITANIUM ALLOYS (BEYOND 1955)

COMPANY	MATL.	FORM	GAGES & SIZES	TYPE OF APPLICATION	MINIMUM GUARANTEED MATERIAL PROPERTIES — ROOM TEMPERATURES				MATERIAL PROPERTIES — ELEVATED TEMPERATURE							FORM-ABILITY	OTHER REQUIREMENTS — WELDABILITY		HEAT TREAT	OTHER	WAG. OF USAGE	SIGNIFICANCE OF USAGE
					U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	OTHER	TEMP. °F	TIME TEMP. HRS	U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOTWELD			% AIRFRAME WEIGHT	
Boeing (Seattle)	C.P. Ti	Sheet	.012 - .125	Non-Struct.	75	60	15		RT-2000	.25-1000						3T	Yes	Yes			1.0	Wt-Sav.
	Ti Alloy	"	.012 - .250	Struct.*	150-180	130-160	15		800-1000	1000	20%	Decrease from R.T. Properties			1	3T	Yes & No	Yes & No			17.0	Required
	"	Extrus.		"	180	160	15		800	1000	20%	"	"	"	1		Desired	Desired				"
	"	FL & Bar	to 500 lbs.	"	180	160	15		800	1000	20%	"	"	"	1		Desired	-			2.5	"
	"	Forging	to 1000 lbs.	"	180	160	15		800	1000	20%	"	"	"	1		Yes & No	-			8.0	"
	"	Tubing	to 100 lbs.	"	180	160	15		800	1000	20%	"	"	"	1		" "	-			.5	"
	"	Fasten.	- -	"	160	150	8		800	1000	160	150	8		1		-	-			1.0	"
																				Total	30.00%	
Martin	Ti Alloy	Sheet	.016 - .125	Str. & Non-Str.	100-150	75-130	20-10		400-800	5000	60-100	40-70	10			Moderate	Yes & No	Yes & No	Yes & No		Neg.	Normal
	"	Bar & FL	to 10x10x50" to 900x100x625"	Struct.	150	130	10		200-400	5000	1000		70			Slight	No	No	No	Mach.	25.5	"
																				Total	25.5%	
Fairchild	C.P. Ti	Sheet	.040	Non-Struct.	90	90	Normal		800	Indef.	50	30	12		Crack. Resist.	Good	-	Maybe	No		5.0	Required
	Ti Alloy	"	.016 - .090	Struct.	150	125	20		1000	"	100	80	12			Good		Yes	Yes		10.0	Sign. Wt-Sav.
	"	Forging	to 10x10x100"	"	180	150	12	Normal								Forge	Flashwl.	-	"		5.0	"
																				Total	20.00%	
Boeing (Wichita)	(Not Answered)																					
Piasecki	(No rational figures can be assigned at present.)																					
Douglas	C.P. Ti	Sheet	.016 - .125	Str. & Non-Stru.	65-80	55-70	20-15		RT-600	Contin.						Mild to Severe	Yes & No	Yes & No	No		8.5	Wt-Sav.
	"	Tubing	1/4 - 2" Dia.	Fluid Lines	80	70	15									"	No	No	"		.50	"
	Ti Alloy	Sheet	.016 - .125	Struct.	100-140	90-130	15-10		RT-725	Con-10hrs.						"	Yes & No	Yes & No	Yes & No		6.00*	"
	"	Bar	Thru 6" Dia.	" (Bolts-Fitt)	140-180	130-160	10									Hot Upset None	"	No	No	Brazing	3.0	
	"	Plate	to 5/8" Thick	"	"	"	10		RT-250	Cont-10hrs.						None to Mild	"	No	No			
	"	Forging	to Press Capacity	"	"	"	10									—	No	"	Accept		4.50**	
																				Total	22.50%	

Calc.			DATE
Des.			
Ckd.			
Appr.			
Appr.			

TABLE II - FUTURE TITANIUM USAGE REQUIREMENTS

BOEING AIRPLANE COMPANY
SEATTLE 14, WASHINGTON

DATA SHEET

BAC 380 A-83

1 Creep Strength Required

* This per cent includes only
No percentage is given for
and Nose Ribs.

** This per cent does not incl
fus., tail, landing gear, e

SUMMARY OF TABLE II REPLIES (PAGE 2)

TURE USAGE REQUIREMENTS FOR TITANIUM AND TITANIUM ALLOYS (BEYOND 1955)

NTEED S	MATERIAL PROPERTIES — ELEVATED TEMPERATURE							FORM-ABILITY	OTHER REQUIREMENTS — WELDABILITY		HEAT TREAT	OTHER	MAG. OF USAGE % AIRFRAME WEIGHT	SIGNI-FICANCE OF USAGE	REMARKS
THER	TEMP. °F	TIME TEMP. HRS	U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOTWELD					
	RT-2000	.25-1000					1	3T	Yes	Yes			1.0	Wt-Sav.	
	800-1000	1000	20%	Decrease from R.T. Properties			1	3T	Yes & No	Yes & No			17.0	Required for Performance	
	800	1000	20%	"	" "	"	1		Desired	Desired				"	" "
	800	1000	20%	"	" "	"	1		Desired	-			2.5	"	" "
	800	1000	20%	"	" "	"	1		Yes & No	-			8.0	"	" "
	800	1000	20%	"	" "	"	1		" "	-			.5	"	" "
	800	1000	160	150	8		1		-	-			1.0	"	" "
												Total	30.00%		
	400-800	5000	60-100	40-70	10			Moderate	Yes & No	Yes & No	Yes & No		Neg.	Normal	Fire Protect; Web of wing end ribs.
	200-400	5000	1000		70			Slight	No	No	No	Mach.	25.5	"	Machined Support Fittings.
												Total	25.5%		
	800	Indef.	50	30	12		Crack. Resist.	Good	-	Maybe	No		5.0	Required	
	1000	"	100	80	12			Good		Yes	Yes		10.0	Sign. Wt-Sav.	
rmal								Forge	Flashwl.	-	"		5.0	"	
												Total	20.00%		
	RT-600	Contin.						Mild to Severe	Yes & No	Yes & No	No		8.5	Wt-Sav.	% Airframe Weight Dependent on satis
								"	No	No	"		.50	"	factory materials & justification of
	RT-725	Con-10hrs.						"	Yes & No	Yes & No	Yes & No		6.00*	"	weight saving from cost standpoint.
								Hot Upset	None	"	No	Brazing	3.0		
	RT-250	Cont-10hrs.						None to Mild	"	No	No				
								—	No	"	Accept		4.50**		
												Total	22.50%		

1 Creep Strength Required

* This per cent includes only structure usage. No percentage is given for wing skins, ducts, and L.E. skin. and Nose Ribs.

** This per cent does not include weight of forgings for wing, fus., tail, landing gear, structure.

DATA SHEET

SUMMARY OF TABLE II REPLIES (PAGE 3)

FUTURE USAGE REQUIREMENTS FOR TITANIUM AND TITANIUM ALLOYS (BEYOND 1955)

COMPANY	MATL.	FORM	GAGES & SIZES	TYPE OF APPLICATION	MINIMUM GUARANTEED MATERIAL PROPERTIES											OTHER REQUIREMENTS					MAGNITUDE OF USAGE	SIGNIFICANCE OF USAGE	
					ROOM TEMPERATURE				ELEVATED TEMPERATURE							FORMABILITY	WELDABILITY		HEAT TREAT	OTHERS			
					U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	OTHER	TEMP. °F	TIME TEMP HRS	U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOTWELD			% AIRFRAME WEIGHT		
Convair (Ft. Worth)	C.P. Ti	Sheet	Foil 4 x 8	Blanket					2750	Indef.													
	Ti Alloy	"	.008-.064 4 x 8	Str. & Non-Str.	180	140	10		600-3000	10-Indef.	90-130	70-120	30-5			Med. to Good	Yes & No	Yes	Yes & No		10.0	High Wt-Sav.	Wing
	"	Forging	6x6x10" to large	Struct.	180-200	140-150	10		100-1000	2-Indef.	90-190	70-165	30-10				"		"	Machin.	.5	"	Fitt
	"	Bar-Rod	3/16 - 3" Dia	"	190-200	120-150	15-10		100-570	2 to ?	100-	70-	30-				"		"	"	1.0	"	Bolts
	"	Cable	3/32- 1/2" Dia	"	200-300		5		500	50	200-300		5								Mag.		Cont
	"	Extru.	3x2x8 to any.	"	170-200	140-150	10		100-570	2 to ?	90	70	30			Medium				"	"	"	Spar
	"	Tubing	1/4to 6" Dia. .020-.125 W.	"					500-1000	Indef.	75-150	30-135	10			Med. to Good	Yes			"	"	Moderate Wt-Sav.	Struc
																				Total	12.0%		
Convair (San Diego)	(Not Answered.)																						
Republic	Ti Alloy	Sheet	.012 - .125		120	110	10		500 to -65	5 to Indef.	100	80	12			High			As Received		100	Imperative High	
	"	Plate	.125 - .250										10										
	"	Bar			140	130	10		500 to -65	5 to Indef.	110	80	12			High			As Received	Total	100%		
													10										
					WITH INCREASE TO FOLLOWING PROPERTIES AS SOON AS POSSIBLE:																		
					150	140	12-15		500	5	115	85	10										

Calc.		REVISED	DATE	TABLE II - FUTURE TITANIUM USAGE REQUIREMENTS
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Chk				BOEING AIRPLANE COMPANY SEATTLE 14, WASHINGTON
Aggr.				
Aggr.				

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SUMMARY OF TABLE II REPLIES (PAGE 3)

REQUIREMENTS FOR TITANIUM AND TITANIUM ALLOYS (BEYOND 1955)

ANTEED MATERIAL PROPERTIES								OTHER REQUIREMENTS					MAGNITUDE OF USAGE	SIGNIFICANCE OF USAGE	REMARKS
E	ELEVATED TEMPERATURE							FORMABILITY	WELDABILITY		HEAT TREAT	OTHERS	%		
OTHER	TEMP. °F	TIME TEMP HRS	U.T.S. KSI	T.Y.S. KSI	ELONG. % IN 2"	STRESS RUPTURE	OTHER	BEND RADIUS	FUSION	SPOTWELD			AIRFRAME WEIGHT		
	2750	Indef.													
	600-3000	10-Indef.	90-130	70-120	30-5			Med. to Good	Yes & No	Yes	Yes & No		10.0	High Wt-Sav.	Wing Ld. Edge, Cowling, Fairing, Fires
	100-1000	2-Indef.	90-190	70-165	30-10				"		"	Machin.	.5	"	Fittings
	100-570	2 to ?	100-	70-	30-				"		"	"	1.0	"	Bolts, Nuts, Fittings.
	500	50	200-300		5								Negl.		Control Cables.
	100-570	2 to ?	90	70	30			Medium				"	"	"	Spar Caps, Structure.
	500-1000	Indef.	75-150	30-135	10			Med. to Good	Yes			"	"	Moderate Wt-Sav.	Structural, Ducts.
												Total	12.0%		
	500 to -65	5 to Indef.	100	80	12 10			High			As Received		100	Imperative Highly Important	
	500 to -65	5 to Indef.	110	80	12 10			High			As Received	Total	100%		
G PROPERTIES AS SOON AS POSSIBLE:															
	500	5	115	85	10										

DATA SHEET

purpose of directing their efforts toward development of facilities and alloys adequate for production of future aircraft. It is believed that the aircraft industry has arrived at the point at which the inadequacy of present structural materials is the critical factor limiting performance of aircraft now in the design stages.

PART III. TABLES AND FIGURES

Table I. C. P. titanium and titanium alloy usage requirements (present through 1955).

Table II. C. P. titanium and titanium alloy usage requirements (beyond 1955).

Figure 1. Present and future maximum weight requirements of C. P. and alloy titanium sheet.

Figure 2. Present and future maximum weight requirements of C. P. and alloy titanium forging, plate or bar.

Figure 3. Present and future size requirements of extrusions and tubing of C. P. and alloy titanium.

Figure 4. Present and future required minimum guaranteed ultimate tensile strength C. P. titanium sheet.

Figure 5. Present and future required minimum guaranteed ultimate tensile strength, titanium alloy sheet.

Figure 6. Present and future required minimum guaranteed ultimate tensile strength, titanium alloy forging, bar and plate.

Figure 7. Present and future required minimum ultimate tensile strength, tubing and extrusions.

Figure 8. Amount of C. P. and alloy titanium to be used in present and future aircraft in percent of airframe weight.

PART IV. REFERENCES

1. ARTC questionnaire ARTC–WR–52–63 dated August 4, 1952.

2. AIA letter dated December 10, 1952.

3. Proceedings of the Titanium Conference, USAF Titanium Conference held at Headquarters, AMC, March 9–10, 1953.

4. Aircraft Production Resources Agency's letters dated September 26, 1952, and February 20, 1953, Forecast of Titanium Requirements.

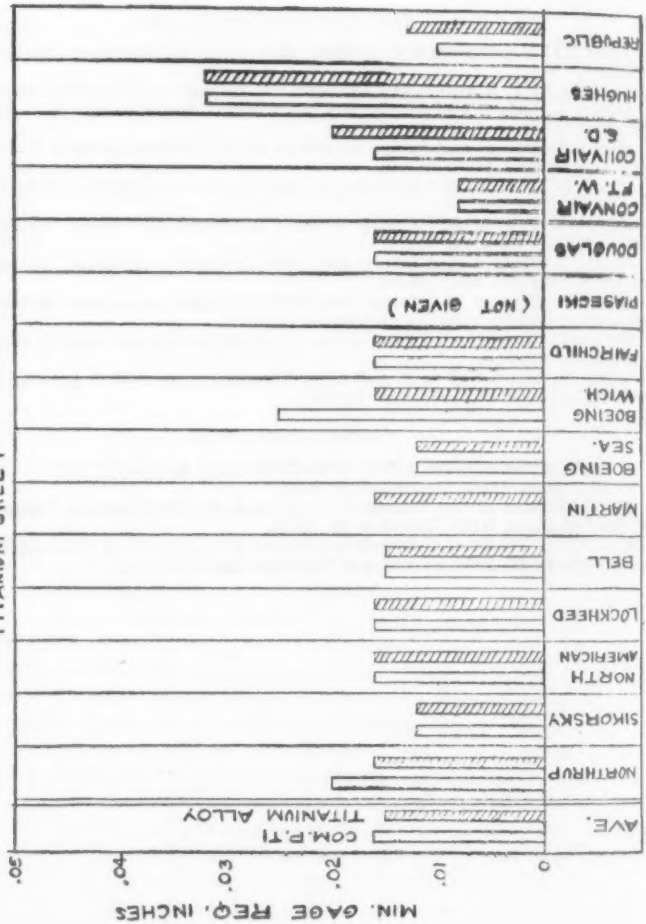

FIG. 1 PRESENT AND FUTURE MINIMUM GAGE REQUIREMENTS OF COM. PURE AND ALLOY TITANIUM SHEET

CALC	T.H. GRAY	4-14-53	REVISED	DATE	GAGE REQUIREMENTS TITANIUM SHEET
CHECK					
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FIG. 2 PRESENT AND FUTURE MAXIMUM WEIGHT REQUIREMENTS OF COMPURE AND ALLOY TITANIUM FORGING, PLATE OR BAR

CALC	THEMAN	4-14-52	REVISED	DATE	WEIGHT REQUIREMENTS TITANIUM FORGING, BAR, PLATE	
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COMPANY	EXTRUSIONS		TUBING			
	MAX. WIDTH IN.	MIN. THK IN.	O.D. IN. MIN.	O.D. IN. MAX.	WALL, IN. MIN.	WALL, IN. MAX.
NORTHRUP	(NOT GIVEN)		→			
SIKORSKY	2.5	—		(NOT GIVEN)		
NORTH AMERICAN	NOT GIVEN		.25	2.	—	—
LOCKHEED	(NOT GIVEN)		→			
BELL	(NOT GIVEN)		→			
MARTIN	(NOT GIVEN)		→			
BOEING, SEA. (AN TYPE) 4.		.04-	.25	4.0	.022	.25
BOEING WICH.	(NOT GIVEN)		→			
FAIRCHILD			.25	2.75	.025	.85
PIASECKI	(NOT GIVEN)		→			
DOUGLAS	(NOT GIVEN)		.25	2.0	-	-
CONVAIR, FT. W.	8.0	—	.25	6.0	0.025	.125
CONVAIR - S.D.	(NOT GIVEN)		→			
HUGHES	—	.05		(NOT GIVEN)		
REPUBLIC	(TO REPLACE PRESENT MT'L)					

MIN. O.D. TUBING - MIN., MAX., & AVE. = 0.25 INCH
MAX." " - MIN. = 2" MAX. = 6" AVE. = 3.5"
MIN. WALL THK - MIN. = .022" MAX. = .025" AVE. = .024"

FIG. 3 PRESENT AND FUTURE SIZE REQUIREMENTS OF EXTRUSIONS AND TUBING OF COM. PURE AND ALLOY TITANIUM.

NOTE - SEVERAL OF THE ABOVE VALUES REFER ONLY TO PRESENT REQUIREMENTS

CALC	T. H. GRAY	4-14-53	REVISED	DATE	SIZE REQUIREMENTS TITANIUM EXTRUSION & TUBING
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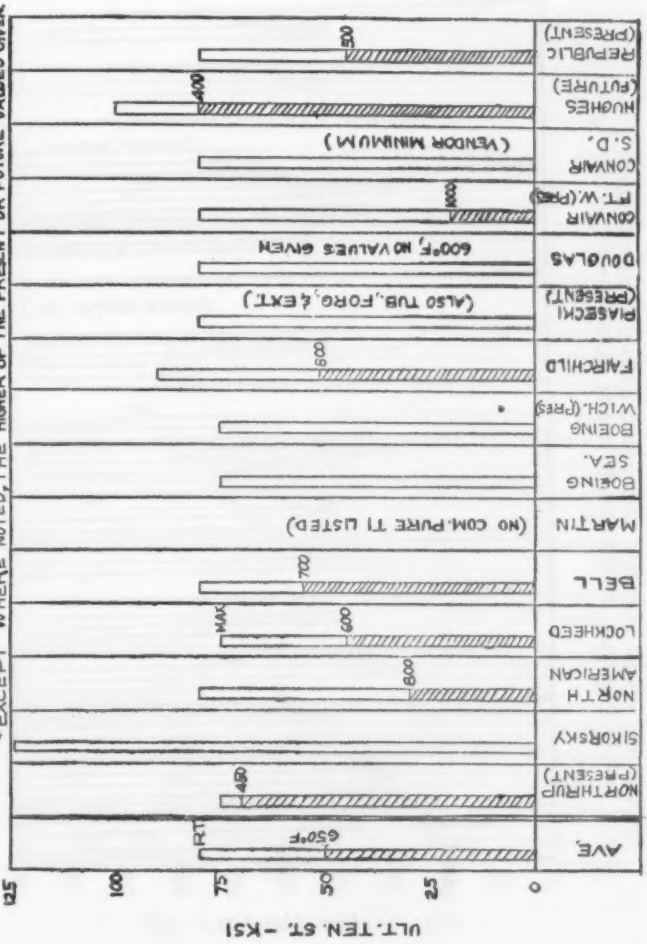

FIG. 4 PRESENT AND FUTURE* REQUIRED MINIMUM GUARANTEED ULT. TENSILE STRENGTH, COM. PURE TITANIUM SHEET

*EXCEPT WHERE NOTED, THE HIGHER OF THE PRESENT OR FUTURE VALUES GIVEN

CALC.	ENGRG	4-14-53	REVISED	DATE	REQUIRED ULT. TEN STRENGTH COM. PURE TITANIUM SHEET	
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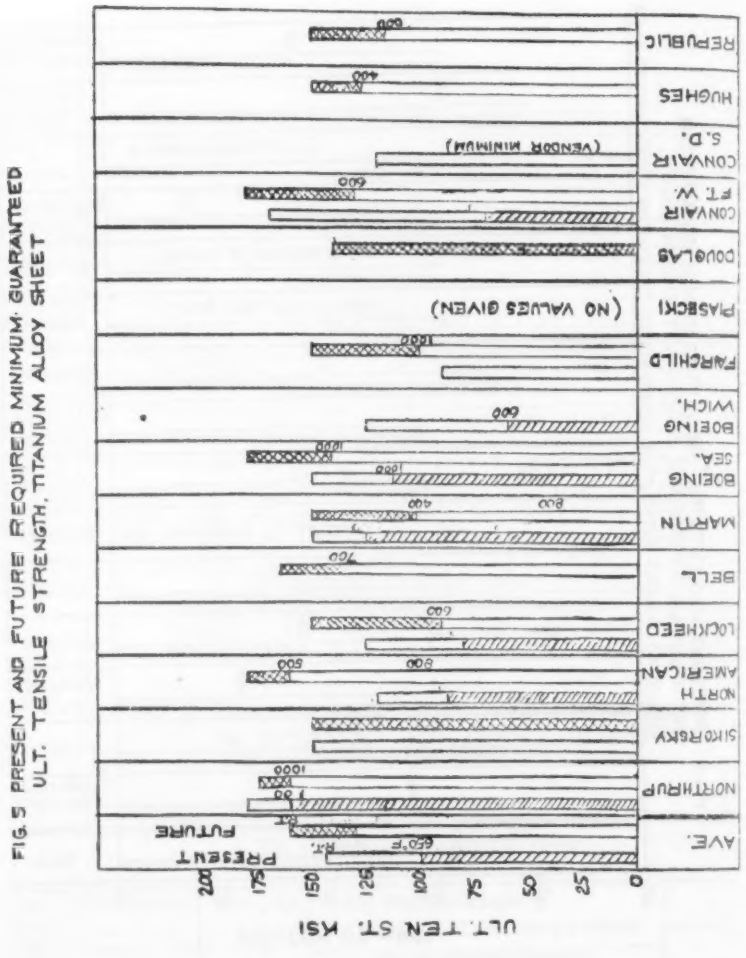

FIG. 5 PRESENT AND FUTURE REQUIRED MINIMUM GUARANTEED ULT. TENSILE STRENGTH, TITANIUM ALLOY SHEET

CALC	T.H. GRAY	4-14-53	REVISED	DATE	REQUIRED ULT. TEN. STRENGTH TITANIUM SHEET (ALLOY)	
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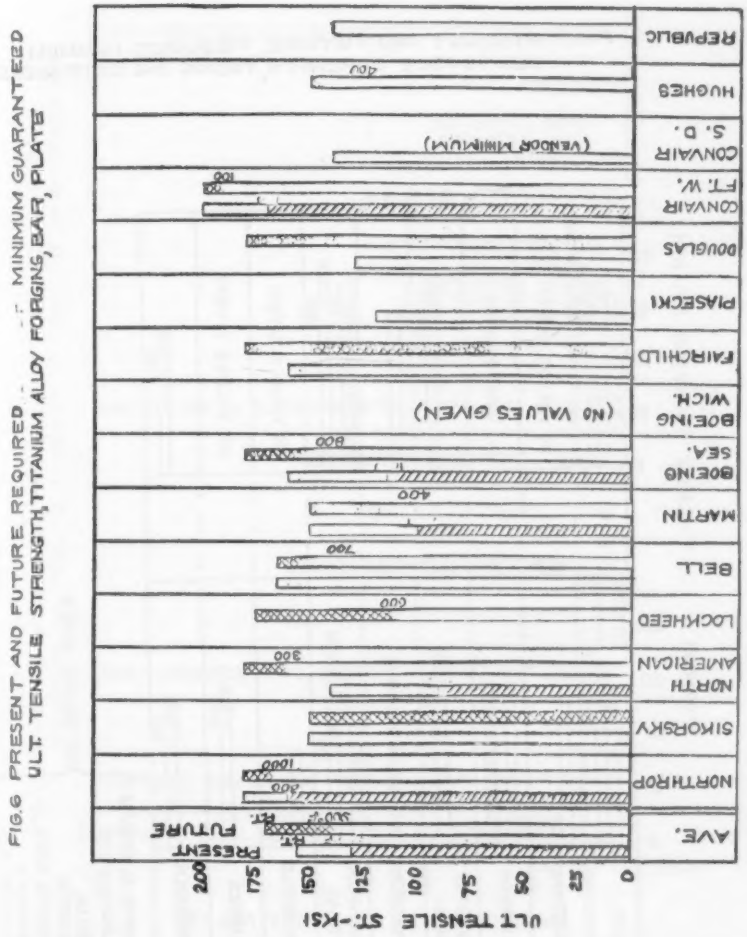

CALC	T.H. GRAY	4-46-52	REVISED	DATE	REQUIRED ULT. TEN. STRENGTH TITANIUM FORGING, PLATE, BAR
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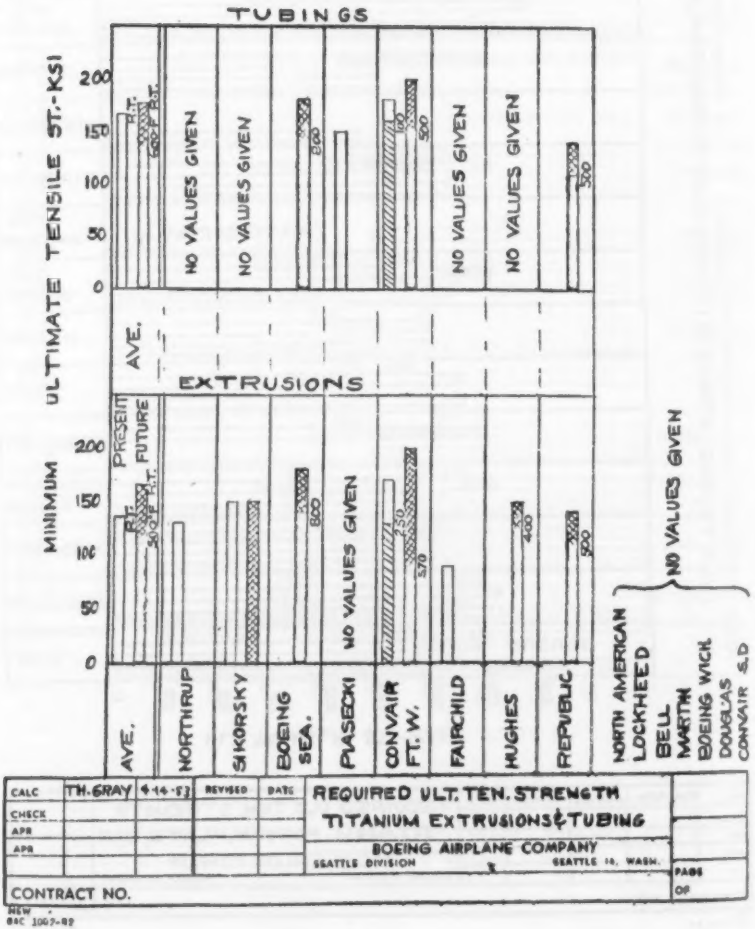
FIG. 7 PRESENT AND FUTURE REQUIRED MINIMUM ULT. TENSILE STRENGTH, TUBING AND EXTRUSIONS



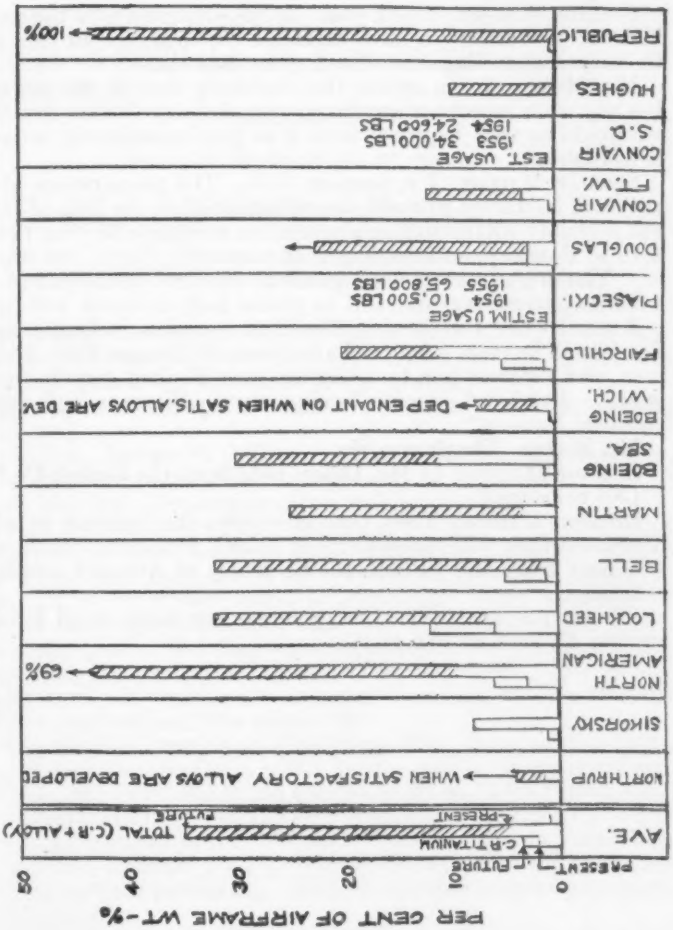


FIG. 8 AMOUNT OF COMPURE AND ALLOY TITANIUM TO BE USED IN PRESENT AND FUTURE AIRCRAFT IN PER CENT OF AIRFRAME WT.

CALC	T.H. GRAY	4-14-53	REVISED	DATE	AMOUNT OF TITANIUM REQUIRED PER CENT AIRFRAME WT.	
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Senator MALONE. Do you have any comments to make?

Mr. MOSIER. No, I have none. I am not a technical man and have no comments to make, except it is a very interesting hearing. I think it is a great story.

Senator MALONE. Thank you. It has surprised even the committee. That is the reason we have extended the hearings on this one particular metal, feeling it is of such great importance.

Mr. MOSIER. I can assure the chairman that if our organization has any more reports or anything, or makes any further investigation, we would be very happy to send it to you immediately, as soon as it is available.

Senator MALONE. I appreciate that. The preparation of our report will be started probably immediately after the 15th of December, but probably will be still in preparation sometime between the 1st and 10th of January, so anything that you might have, you might send in. You might convey my regards to Admiral Ramsey, and tell him we are appreciative, and will he please keep in touch with us.

I recall when I arrived in New Caledonia, or at least some South Sea island, in 1943, Admiral Ramsey was in charge of the fleet in that area, and I missed him by a day or two. He had gone to some other island. But I did miss his headquarters. We have high regard for Admiral Ramsey.

Mr. MOSIER. Thank you, sir.

Senator MALONE. Is Mr. Dixon here from the Ladish Co.?

(No response.)

Senator MALONE. Then that concludes the hearing as of today. The committee will recess until 10 o'clock Friday morning, when we will hear from Mr. Talbott, the Secretary of Air, and possibly other witnesses.

(Thereupon at 11:55 a. m., a recess was taken until Friday, November 27, 1953, at 10 a. m.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

FRIDAY, NOVEMBER 27, 1953

UNITED STATES SENATE,
SUBCOMMITTEE ON MINERALS,
MATERIALS AND FUEL ECONOMICS,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to recess, at 10 a. m., in the committee room, 224 Senate Office Building, Senator George W. Malone, Nevada, chairman of the subcommittee, presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee).

Present also: Jerome S. Adlerman, counsel to the subcommittee, George B. Holderer, subcommittee engineer.

Senator MALONE. The subcommittee will be in order.

Secretary Talbott is here this morning, and will be the first witness.

Mr. Secretary, there has been quite interesting testimony offered on this new metal, titanium. I say new metal, because it is new in industry. It is not a new metal to engineers. They have known about it for many years, like they knew about magnesium and aluminum for many years. But they were not practical for use in industry for many years because of their inaccessibility and cost. I just want to say this before I ask you to make any statement that you care to make on its use in aircraft and its availability.

We held our first hearing at Henderson, Nev., because that is the location of the Titanium Corp. which has the largest Government contract, 10 tons per day. We found for two years and a half production had increased materially, but the corporation still was not up to full production as specified in the contract. We heard the du Pont Corp. It has been let a contract for 7½ tons, which is in addition to the 2½ tons they are already producing. They are not due to come into operation until next year.

But on the 77 materials of strategic and critical importance to this Nation that Senate Resolution 143 directs this committee to study as to their availability in time of war, titanium has developed into one of the most important materials.

We have also dug up some material that is in the record and perhaps you heard about it in past years, that our program should be to save our materials in the United States and secure raw materials from foreign countries. This idea has prevailed. Testimony before this committee, has developed that we are now dependent on foreign nations across major oceans for many central and strategic minerals

and materials, without which we cannot fight a war or maintain our economy.

Testimony also shows that even in peacetime these nations manipulate the amount that can be exported. India shut off the export of monazite sand to this Nation at one time. But whether they are friendly to us in the next war or not probably would be one factor. Another factor is the matter of keeping transportation lines open, and shipping ore or freight across each major ocean. We intend to call the Department of National Defense later on that point.

I know of no major military strategist who thinks you are going to get very much of this material across each major ocean after the fourth world war starts.

There is a very interesting memo from Mr. White, who has become famous after he died and after we defeated the administration that cultivated him, in which he advised the very thing we are doing. He said in one paragraph of a memo of January 10, 1945:

> We could safeguard and conserve our strategic material reserves in postwar years which are now at a minimum level by importing from abroad to meet ordinary annual production requirements.

and recommended Russia very highly as being one of the chief exporters of these materials, and recommended that we obtain these materials from Russia for the next two generations.

On July 23, 1946, Mr. Truman said that the policy of this Government was to work for international action to reduce trade barriers. We have proposed to other countries a set of principles governing trade, and looking for the successful conclusion of broad international arrangements on these proposals. He said:

> I have today signed the Strategic and Critical Minerals Stockpiling Act because it is important to the national interest. It is only because of the overriding importance of this purpose that I am able to overcome my reluctance to sign a bill which reaffirms the application to the stockpile purchases of the provisions of title 3 of the act of March 3, 1933, known as the Buy American Act.

He did not like that. He did not want any tariffs or imports fees. What he wanted to do was to follow this memorandum so that this country would become dependent on foreign nations across the oceans for materials without which we cannot fight.

In titanium that very setup has been followed. This country is now dependent on Australia for rutile, and dependent on India for ilmenite.

Testimony before this committee shows that there is more ilmenite in the United States and southern Canada than you can use in a hundred years, and it is ready.

Mr. Secretary, the chairman of this subcommittee realizes that you have been in office a comparatively short time. We heard the testimony of the man who is supervising the contracts for the General Services Administration, and we learned very little from him. We had Mr. Mansure the General Services Administrator down here right after that, and Mr. Mansure says that something is going to be done about it. In other words, it is important to ascertain who lets these contracts, who follows them through, and who is responsible for our dependence on these foreign nations for raw materials without which we cannot fight a war. Even if you were producing enough titanium, you would have to stop production in a few days after the war had

started due to lack of raw materials, in the opinion of a good many military strategists whom the chairman knows.

Mr. Secretary, the testimony shows that we need from 100,000 to 150,000 tons of this material. It made Gen. Kern Metzger who was our first witness, look very conservative when we consulted Douglas Aircraft, Lockheed, and Boeing, in Los Angeles.

The testimony shows that the Department of National Defense had recommended 35,000 tons annually; that someone, presumably the Office of Defense Mobilization, cut it to 22,000 tons. Contracts have been let for 13,800 tons per year, and we are only producing 2,000 tons now. In addition, we are dependent on foreign shores for practically all the the ore.

So I am going to ask you, Mr. Secretary, realizing full well that the short time you have been in this job would not allow you to become cognizant of all these facts—you have so many other worries—who in the National Defense organization recommends the amounts of these materials you need; who has the authority to cut this amount of your recommendation; and is the General Services Administration the only organization that furnishes any inspection? In other words, what happens after you make your recommendation as to amount of titanium needed?

The first thing would be where did the 35,000-ton recommendation originate.

STATEMENT OF HON. HAROLD E. TALBOTT, SECRETARY OF THE DEPARTMENT OF THE AIR FORCE

Secretary TALBOTT. Senator, I am not conversant with the numbers. As you say, I have been in office for 10 months. This is one of the problems that has been presented to me. It was presented many weeks ago. General Metzger has testified before you, and perhaps he may have been conservative. I do not know about these numbers. I believe that the manufacturers know what they are talking about when they tell you their requirements, thinking into the future. There is no question but that we can use and should have a large supply of titanium. Not only will it be used in the Defense Department in peacetime as well as in wartime, but it will also be used by industry.

Titanium gives promise to be of great value to us, and I believe that we should without delay proceed to increase our production. We are talking about 35,000 tons or 50,000 tons or 150,000 tons. At the present time, as you bring out, we are woefully weak in producing 2,000 tons. I think that we should proceed immediately to increase it and increase it as fast as we can.

Where those numbers go, we have to get the 5,000 tons, 10,000 tons, 15,000 tons, and move forward on it. I think we should encourage any sound American organization with the technological ability, with the engineering and research ability, and the resources to proceed, if any of them will proceed, and we should encourage them.

How that encouragement should come, I do not know. But it seems to me we should at least guarantee to accept from those organizations enough product to amortize their plant. I think when a company comes in with some pilot-plant work which looks as though they had a process that would produce titanium, that we should encourage them

and possibly help them financially with a good pilot plant before they go into production.

The titanium production which we require will take the full ability of not one but many manufacturing organizations or producing organizations. I have never seen any metallurgical problem presented where if we have a real content of a valuable strategic metal in an ore we were not able to eventually get it out and get it out economically.

I am thoroughly alive to the many uses that titanium will have, and where it will be a great asset to us. I hope with the efforts of your committee, the efforts of the Defense Mobilization group and the Defense Department that we will move forward on this titanium production as rapidly as possible.

That is a summary of my thinking. I have gone over these figures with General Metzger, and with Assistant Secretary Roger Lewis, who is conversant with this problem, and while I am not an authority in any way on it, I have enough knowledge to know that we have got to move forward on the titanium production with all vigor and to get some real production quantity.

Senator MALONE. Mr. Secretary, I fully realize the truth of what you have just said, and the fact you were not in office until this year, so that you are not responsible for what went on before. But from now on, you will be, of course.

Do you agree, from the study you have made, with the testimony of the engine and plane manufacturers which has been available to you, that with respect to any future plans for warplanes, titanium is a must?

Secretary TALBOTT. In the future, yes. At the present time it would be of great value to us. In the future it is a must.

Senator MALONE. I will not try to quote General Metzger's testimony, because it is available to you, and the principal reason for asking you to come here was to hear what you just said, that you are going to review this situation and from now on see that production is accelerated. I understood your testimony to add up to that statement.

Secretary TALBOTT. I have great confidence in our manufacturers. They are not going to give you figures that are clearly wrong. They may make a mistake, surely, but when you can get a material that weighs 40 percent less than steel, with the same physical characteristics, it means a terrific saving to us if we can get that metal in all phases of our aircraft construction.

Senator MALONE. You are familiar with the testimony, of course, that in certain speeds sonic and above which we are trying to reach, that this is about the only material available that will stand the necessary heat without using steel, which is so heavy it is almost prohibitive.

Secretary TALBOTT. Yes, I am conversant with those ranges of speed where titanium will be avisable or necessary.

Senator MALONE. It has also been testified to many times and I would like to know if you agree, that if a potential enemy had this material available for the manufacture of their aircraft, and we did not have it, we would be in a very inferior position.

Secretary TALBOTT. That is correct.

Senator MALONE. When we send these boys into the air after years of training, they are at least entitled to an even break. You agree with the chairman on that premise.

Secretary TALBOTT. Yes, of course.

Senator MALONE. What about the matter of securing raw material for the manufacturers? I am speaking of the necessary war material. Do you agree with Senate Resolution 143 that we should thoroughly investigate the availability of critical and strategic materials, and wherever we can secure a raw material either within our own Nation or in the Western Hemisphere, where the likelihood of protection lanes is at least much better?

Secretary TALBOTT. Surely.

Senator MALONE. You are familiar that we are getting rutile from Australia and ilmenite from India?

Secretary TALBOTT. Yes, I am. I also understand we have quantities of that ore available in this country, or have a satisfactory ore.

Senator MALONE. They say, Mr. Secretary, that the thing that makes titanium so available and attractive, is that the raw material from which titanium is produced, is the fourth most plentiful metallic mineral in the earth's surface. The Kennecott Copper Co. testified here that they are ready to produce, and are producing ilmenite in great quantities in Canada and nearby areas. They testified that several hundred million tons of the raw material are available.

I might ask this: Do you favor getting strategic and critical materials from the United States or the Western Hemisphere, when they are available?

FAVORS DOMESTIC RAW MATERIAL

Secretary TALBOTT. We should have our own production and protect ourselves here in this country. Where we have an ample supply of raw material, I see no reason for bringing raw material from other countries.

Senator MALONE. You are familiar with the recommendation made to Mr. Morgenthau by Mr. White that we do just that, and the recommendation from Mr. Truman to the stockpile authorities and other Government agencies warning that these materials should be imported.

Secretary TALBOTT. I was not conversant with that at all.

Senator MALONE. The committee has testimony to the effect that planes are now on the drafting board, but they do not dare use these designs because titanium is not available and there is no prospect of it being available. In other words, there has been no concerted movement by the powers that be in Washington to show that increased titanium production is even on the way.

We have had testimony here by several organizations, including the Massachusetts Research Institute, headed by Mr. Morse, who testified they have a feasible process.

Union Carbide said it has a feasible process, and is willing to make a contract with the Government on the present price for delivery in 2 years if the Government will take that part of the next years' supply not absorbed by the market. Union Carbide will put up its own money to build the plant, which would amount to $30 million or $40 million.

The Crane Co. was finally granted a 15-ton contract, but it took a year, or a year and a half of negotiations before that contract was let. I believe Cramet is now located in Tennessee.

There is no dearth of people who want to spend their money in this field, but there is testimony, I am sorry to say, that there is a great

dearth of any attention being given to this field by any Government agency.

Secretary TALBOTT. Mr. Chairman, I will tell you that we are thoroughly alive to it now in the Air Force, and we expect to move and do something about it, because we need it and it is available if the proper action is taken. I am sure that the Secretary of Defense, when he has an opportunity to be conversant with this matter, will take exactly the same position.

Senator MALONE. Let me ask you then, Who makes the original recommendation as to the amount of materiel necessary for your plans?

Secretary TALBOTT. I think we have specified our requirements.

Senator MALONE. Only for the Air Force.

Secretary TALBOTT. Yes.

Senator MALONE. Would you presume that the Navy and Army also make their own recommendations?

Secretary TALBOTT. That is right.

Senator MALONE. To whom do you send your recommendations?

Secretary TALBOTT. They go to the Defense Secretary's office. I do not know what the Department has had to do with this. I do not know what the machinery has been in stating our requirements, and the study we have made to prove that the requirement is a real requirement.

Senator MALONE. Do you know what recommendations the Air Force has made to the Secretary of National Defense?

Secretary TALBOTT. I think General Metzger has told you that. He is thoroughly conversant with the detail of those requirements.

NEED 28,000 TONS BY 1956

Senator MALONE. General Metzger has told me what, in his opinion, you need. He did not tell me what you recommended. I do not think I asked him the question, "Who makes that recommendation?"

Secretary TALBOTT. I do not have that figure. Can you give that figure, General Metzger?

General METZGER. Yes, sir, I can give that figure.

Senator MALONE. What is the figure fixed by the Air Force, excluding Navy and Army requirements for the moment, as to amount of titanium necessary now and in the future?

General METZGER. Senator Malone, it is my recollection that the requirements, given us by the Department of Defense last June, were supplied as a joint requirement of the Air Force and the Bureau of Aeronautics. The requirement was stated to be 28,000 tons, as I recall, for the Air Force and the Bureau of Aeronautics, by 1956.

Senator MALONE. That includes all the requirements for air branches of the Department of National Defense.

Secretary TALBOTT. That is correct.

General METZGER. I might say, Mr. Chairman, that the guideline or the framework within which this requirement was generated was specified by the Department of Defense, and did have a price ceiling for application and a firm program planning requirement.

Senator MALONE. What was the price ceiling?

General METZGER. $15 a pound, as I recall it.

Senator MALONE. Five dollars for sponge?

General METZGER. It was $15 per pound, sir. We are only interested in titanium in mill shapes, and not sponge titanium.

Senator MALONE. The $15 a pound was for the sheet rolled material.

General METZGER. Or bar stock.

Senator MALONE. And 28,000 tons were required for the air branches alone.

General METZGER. That is my recollection, by 1956.

Senator MALONE. The additional 7,000 tons, to make the full 35,000 tons recommended, must have come from the Army and the Navy.

General METZGER. Yes; I would assume so, sir.

Senator MALONE. You have no knowledge whether it was more than 7,000 tons, and the Secretary of National Defense Office cut might have been made on all 3, and then added up to 35,000 tons?

General METZGER. I have no knowledge on that all, Mr. Chairman.

Senator MALONE. Mr. Secretary, you could get that information for the committee, could you not?

Secretary TALBOTT. Yes, sir.

Senator MALONE. Will you furnish to the committee your orginal recommendation, the recommendations of the Navy and Army and the total recommendation from the three arms of the service?

Secretary TALBOTT. I will do that, sir.

(See letter, p. 585).

Senator MALONE. The testimony of course shows that you need a tremendous amount more than the 28,000 tons by 1956, or even now. Is that true, General?

General METZGER. Pardon, sir.

Secretary TALBOTT. Senator, we could not use it immediately. It would take a little period of time to design the titanium into the construction of planes.

Senator MALONE. Who does the designing?

Secretary TALBOTT. The design is done usually by the manufacturers.

Senator MALONE. The manufacturers' testimony is that they have the designs, but they do not dare take them farther than the drafting table.

Secretary TALBOTT. Even if they have the designs, by the time they tool them and bring it through, they could not use it today, for example. It would be a period of months.

Senator MALONE. When do you think they could use it? Have you determined that point?

Secretary TALBOTT. I have not determined that point. Certain parts could be made very quickly. Certain parts would take a long period because of the tooling, the metallurgical treatment after the parts are made, and a great many other reasons.

Senator MALONE. Mr. Secretary in my opinion this is the important part of the problem. The testimony has been that since there has been and is no serious attempt to get the amount of titanium production they need, they have lost interest in trying to get the plans off the drafting board. They are making not attempt to do that, because they do not have titanium, and they do not see any prospect of getting titanium in the near future.

Secretary TALBOTT. I think that is correct.

Senator MALONE. Who is responsible now for obtaining increased production?

Secretary TALBOTT. I think it is our responsibility now. We will assume it, and go after it.

Senator MALONE. Thank you. I was going to read some of the testimony.

Secretary TALBOTT. Is that correct, General?

General METZGER. Yes, sir.

Senator MALONE. The three arms of the services, present their recommendations to the Secretary of Defense, who makes the ultimate recommendation. Do these recommendations then go to the Office of Defense Mobilization?

Secretary TALBOTT. Senator, I do not know that. I can assure you of this, that in no instances of this kind have we not had complete support from the Office of Defense.

Senator MALONE. I do not know whether you would call it complete cooperation or not.

Secretary TALBOTT. I feel responsible that this problem has not come up vividly in my mind at an earlier date.

Senator MALONE. I understand that.

Secretary TALBOTT. I am ashamed that I have not gotten into it earlier.

Senator MALONE. Mr. Secretary, you are not being blamed for this situation. The committee was not organized to take anyone to task. That is not the purpose of the committee. The purpose of the committee is simply to call to the attention of the proper department the 77 strategic and control minerals and materials.

I understand you will furnish information to the committee as to the procedural steps your recommendation takes; how much of this particular material was recommended by each branch of the service; and who determined the final recommendation. If the recommendation of the Department of National Defense is submitted to the Office of Defense Mobilization we would like to know who cut the recommendation to 22,000 tons.

We are trying to fix the responsibility, and are not blaming the Office of Defense Mobilization any more than we blame you. As the chairman understands it, the Office of Defense Mobilization is new, and represents the consolidation of the efforts of 40 or 50 of these organizations where the ball was thrown around for months and nobody knew where it was. Maybe we can find it.

Secretary TALBOTT. Yes, sir.

Senator MALONE. We would also like to know why the recommendation was cut to 22,000 tons; and who is responsible for letting and supervising the contracts. Do you believe the General Services Administration is the responsible agency?

Secretary TALBOTT. I do not know.

Senator MALONE. Will you find that out?

Secretary TALBOTT. Yes; I will find out.

Senator MALONE. Also whether the General Services Administration conducts an inspection to see that the contracts are performed on time? Would you get us that information also?

Secretary TALBOTT. Yes, sir.

(The information is as follows:)

DEPARTMENT OF THE AIR FORCE,
OFFICE OF THE SECRETARY,
Washington, December 15, 1953.

Hon. GEORGE W. MALONE,
Chairman, Minerals, Materials, and Fuels Economic Subcommittee,
Committee on Interior and Insular Affairs, United States Senate.

DEAR MR. CHAIRMAN: During the course of the recent hearings conducted by your subcommittee regarding production of titanium, you requested Secretary Talbott, who appeared before your subcommittee on November 27, to provide you with certain information, in response to questions presented by you, which was not readily available at that time.

I am pleased to submit the enclosed summary sheet to you which sets forth this information in detailed question and answer form and which it is hoped will be satisfactory for your purposes.

Sincerely yours,

ROGER LEWIS,
Assistant Secretary of the Air Force.

SUMMARY SHEET

Information on titanium production requested during hearings conducted by the Minerals, Materials, and Fuels Economic Subcommittee, Senate Committee on Interior and Insular Affairs.

1. Question. What were the quantities of titanium originally recommended to the Department of Defense by the Army, Navy, and Air Force?

Answer. The titanium requirements submitted by the services are:

	Tons
Army	800
Navy	3,000
Air Force	24,600
Total	28,400

A production goal of 35,000 tons was recommended by the Department of Defense to allow for additional potential military and essential civilian requirements.

2. Question. It is understood that the Department of Defense recommended 35,000 tons to the Office of Defense Mobilization. Why did the latter cut this recommendation to 22,000 tons?

Answer. The reasons given by the Office of Defense Mobilization for establishment of a reduced expansion goal are contained in a letter dated September 19, 1952, addressed to the Vice Chairman for Materials, Munitions Board, from the Director, Military and Atomic Energy Division, Defense Production Administration. A copy of that letter is attached hereto.

3. Question. Who (what office, specifically) makes these recommendations to the Department of Defense? To the Office of Defense Mobilization? To the General Services Administration?

Answer. The military services submit requirements to the Department of Defense through offices as follows:

(*a*) Air Force, Office of the Assistant Secretary (Materiel).
(*b*) Army, Office of the Assistant Secretary (Materiel).
(*c*) Navy, Office of the Assistant Secretary.

The Office of the Assistant Secretary of Defense (Supply and Logistics) submits consolidated requirements to the Office of Defense Mobilization. The Office of Defense Mobilization then certifies a program and authorizes the General Services Administration to proceed within the scope of the certification.

4. Question. Who follows through on the allocations and contracts involved to see that titanium production is satisfactorily accomplished?

Answer. The contracting agency, Emergency Procurement Service of the General Services Administration (successor to the Defense Materials Procurement Agency) follows through on contract.

DEFENSE PRODUCTION ADMINISTRATION,
Washington 25, D. C., September 19, 1952.

Mr. NATHANIEL KNOWLES, Jr.,
Vice Chairman for Materials, MB,
Washington 25, D. C.

DEAR MR. KNOWLES: This is to advise you that the expansion goal for titanium is being reduced from 35,000 tons annually to 20,000 tons annually.

The reasons for this reduction are as follows:

(1) The Kroll process for making titanium sponge is extremely complex and uneconomical. With the amount of research that is currently being applied to this problem by the laboratories of some of the largest corporations of the United States, it is a good assumption that there will soon be a more economical process for making the sponge or a similar material and any plants erected with Government funds, using this present Kroll process, would become obsolete overnight. As you know, the estimated capital cost of new facilities to produce 27,500 tons of sponge over and above the present existing capacity of approximately 7,200 tons per year is $140 million.

(2) In calendar year 1952, the total cost of all materials, aluminum, steel, copper, rubber, etc., at current market prices used in the aircraft program will cost approximately $560 million. In the year 1953, the total annual capacity of titanium metal production will be something over 40 million pounds and the great majority of this metal is destined for the aircraft program. The average price for titanium products is $15 per pound. Thus, for one metal an expenditure of $600 million must be made for the military aircraft program, which exceeds the total spent for all metals in 1952—the peak year for materials procurement for the present aircraft schedules.

(3) The consensus of opinion of all industry men in DPA who are familiar with this metal is that the goal of 20,000 tons is sufficient until more advanced technological knowledge is available concerning this metal.

(4) The staff of the DPA is also of the opinion that it will be necessary for the Government not only to finance the construction of the new titanium sponge plants but also to provide a guaranty purchase program for all titanium sponge produced under this expansion plan. For this reason alone it is felt that the Government should proceed into this program on a more moderate basis than would be the case if a 35,000-ton goal were established.

This expansion goal of 20,000 tons will be reviewed within the next 6 months for possible further revision. If at that time the Department of Defense has more definite requirements than under its current submission and if the titanium metal then being produced is all being picked up by firm orders, I am sure an upward revision in this goal can be made without undue difficulty.

Sincerely yours,

W. N. LAWRENCE,
Director, Military and Atomic Energy Division.

Senator MALONE. We intend to have Mr. Flemming of the Office of Defense Mobilization. We called him among the first witnesses, but mostly just to get acquainted with him. After we have received information as to the availability of these materials and know exactly what is being done in each one of them, we will call Mr. Flemming again.

It seems to me that the evidence contains material that would be helpful to him, as well as to you.

The testimony of Mr. Gross, Mr. Papin was his expert, was that "Today's airplanes could use 21 to 25 percent right now."

They are actually using about 3 percent. They could use 21 to 25 percent. General, you correct me if I am wrong. I have had the General with me as an expert, and I recommend him, Mr. Secretary.

Secretary TALBOTT. I recommended him, too.

Senator MALONE. I think someone like the general ought to be designated to follow through on this matter because he has studied the situation, knows what is necessary, how to get it, and understands the processes as well as anybody. That is not a criticism of your Department.

Secretary TALBOTT. I might say for your information, Mr. Chairman, that General Metzger is a businessman of many, many years' experience.

Senator MALONE. I know that.

Secretary TALBOTT. He has given his time unselfishly to the Air Force, and is of great value to us.

Senator MALONE. I am glad to hear you say that, Mr. Secretary. It did not take me very long to get permission to use him in these hearings. While I have been in the engineering business 30 years, I have not been in the titanium business, and it is a specialized business.

Industry witnesses testified—and General, correct me if I am wrong, because I want to give the Secretary some indication of what has been done—that if they had the titanium, and knew they were going to have it, they would bring the plans off the boards to use as high as 40 percent titanium in the planes.

General METZGER. In fighter-type aircraft principally, with a smaller percentage in heavy bombers or cargo-type aircraft.

Senator MALONE. What would that percentage be?

General METZGER. It ranged from 10 to 25 percent in the estimate of those testifying.

Senator MALONE. Did we not have testimony here, that the titanium in the engines could at the present time be about 40 percent if they knew they were going to have it, and was there not testimony that they could probably go up to 90 percent eventually?

General METZGER. Mr. Chairman, I do not think it was quite that high.

Senator MALONE. Let us confine it to the 40 percent. Is that not about what they could use almost immediately?

General METZGER. As rapidly, Mr. Chairman, as the material became available in the quality and the alloying which was required to process the parts they had in the design.

Senator MALONE. Then that is exactly my point. In other words, if you had it at this moment you would be using it next year, Mr. Secretary. You have not got it. Probably it will take 2 years if you start now. But whenever you get it, they will use it.

Testimony was presented here the day before yesterday that in one of these engines of the big bombers, where there would be 8 engines, that you could save 3,500 to 4,000 pounds per engine. That is correct; is it not?

General METZGER. Sir, that was total. That was based on an estimate of 500 pounds per engine saving at this point. It was 4,000 pounds total engine-saving weight.

Senator MALONE. Probably you and I, Mr. Secretary, would not know what that meant to a designer of an airframe, but the experts do, and they say that makes the difference between a plane that may survive in the next war and probably one that would not last very long.

Secretary TALBOTT. I think I know a little about that. I spent the day before yesterday at Pratt & Whitney, and went over the parts that they could use where they could replace steel with titanium. So I am not unconversant with some of these uses.

Senator MALONE. Mr. Secretary, what this committee would like to do is to work with you. Would you keep us advised as to what you

are doing in this regard? While our report goes into the Senate in January, we do not propose to drop the work. We intend to keep in touch with it, and be just as helpful as we can. If you would furnish us any information that you would think would be important to the committee, so that the Senate might be helpful to you, it would be appreciated.

We realize that Government officials, after they have been there for a while, like to stay, and maybe they are sometimes a little hesitant in making recommendations that would cost a good deal of money. If the Senate can be made conversant with what is going on, perhaps the Senators themselves would be on your side, then maybe the Government officials would not be so hesitant in going into a new field.

We have had much testimony that this material would probably follow the course of many other materials, notably magnesium and aluminum, and other scarce materials. Some witnesses seem to think a new process will come up before long—Union Carbide, for one, testified it is going direct into the metal, and miss the sponge production entirely that costs $5 a pound. Many witnesses believe if we are under real production in the foreseeable future, the price would come down $2 or $3 a pound, which looks phenomenal from what it costs now, $15 a pound.

When you look into the history of aluminum, it cost $50 a pound at one time, and of course no one could use it except in special cases. Titanium is a must material. If an enemy had planes made out of it, and we did not have it in our planes, we would not be prepared, no matter how many planes we had.

AGREES ON NEED

Secretary TALBOTT. Senator, it is a must that we have a proper supply of titanium.

Senator MALONE. Then, Mr. Secretary, would you furnish the information for the committee at your earliest convenience as to who makes these recommendations in the National Defense organization, to whom they make them, and who, if anyone, has the right to cut this requirement, and whether the Defense Department recommendations must then be approved by one or more additional agencies?

Secretary TALBOTT. We can get that information for you. Our contact is the Office of the Secretary of Defense, and that is where we send our recommendations. You have asked me to find out what the Secretary of Defense's office does with those recommendations. I do not know whether you plan to call anyone from the Secretary of Defense's office or not.

Senator MALONE. I will call them if it is necessary. It may not be necessary at all if we can get all of the information.

Secretary TALBOTT. I would like to go to Secretary Wilson and Secretary Kyes and ask for this information, or if they prefer, to have someone from the Defense Department come before this committee and give that information.

Senator MALONE. They would be very welcome.

Secretary TALBOTT. If they want to do it, I will be very glad to do it. If they prefer someone else, they can so state.

Senator MALONE. If they could at the same time say to whom they send the recommendations.

Secretary TALBOTT. I will tell them exactly the questions you want answered.

Senator MALONE. And then what this further organization is entitled to do with the recommendation.

Secretary TALBOTT. I will go clear through.

Senator MALONE. Mr. Secretary, you asked if we intend to call Mr. Wilson. We do intend to call him on another matter. I was even in hopes that we would not have to call you, but we ran right into a blind alley.

Secretary TALBOTT. We will see if we can help you with the blind alley and obviate the necessity of calling Mr. Wilson. I think the work you are doing is extremely constructive and helpful.

Senator MALONE. Thank you very much. General Metzger has just pointed out to me that 1 pound of weight reduction in the engine could result in a 6- to 10-pound reduction in weight of the airframe. Eight engines at 500 pounds each, a reduction of 4,000 pounds, makes a possible 32,000 to 40,000 pounds total reduction in 1 plane.

Secretary TALBOTT. It is extremely important.

Senator MALONE. It makes the difference some people say as to whether we can reach six or eight or ten thousand miles away and bomb a target and come home, and outfly anybody on the way. The fighters will have more maneuverability, speed, latitude, and greater range.

Secretary TALBOTT. That is the important one.

BIG STICK

Senator MALONE. It is not the intention of the committee right at this moment to go into the defense of any transportation lines or any areas, but if you have these planes, then you are equal to any fighters in the air and any bomber in the air, regardless of what an enemy may have. But if they have it and we do not, as I have said there is no second best poker hand, and there is no second best when it comes to control of the air.

Secretary TALBOTT. That is certainly very true.

Senator MALONE. So with your B–52's, if you have enough of them, and you have enough fighters, and you are ahead in the production of atomic bombs, a good many of us believe that is the best way to prevent a war. Just be ready.

Secretary TALBOTT. We are trying to win a war without fighting it.

Senator MALONE. That makes a lot of sense. Apparently we have followed Mr. White's recommendations and have become dependent on foreign nations, at the moment, for various strategic materials such as manganese when there is enough manganese in the Western Hemisphere to last 100 years. For 20 years we have had a buildup of the idea we must trade with these other nations, that we do not have these materials, and therefore we must save our materials and obtain these materials foreign. So at the moment we are getting eight or nine hundred thousand tons of manganese from India, but if an all-out war started tomorrow, we could not get this manganese due to activities of enemy submarines. I will leave it up to you to look up how much manganese we have in the stockpile. I nearly cried when I found out about it.

I am bothered by the fact that the administration is not aware of the fact that they are following the concept planted by Harry Dexter White and the past administration. Speeches have been made all over the country but I have not heard any speeches on this situation. We have a Randall Commission probably getting ready to recommend we continue this past policy. If it does, I will guarantee you one thing; the fight you will see on the Senate floor will pale all past fights into insignificance.

Mr. Secretary, we appreciate your appearance.

Secretary TALBOTT. Again I say how much we appreciate your effort.

Senator MALONE. We are with you.

Secretary TALBOTT. Thank you, sir.

Senator MALONE. Mr. Rowley, president of the Titanium Corp., is here. Will you come forward?

Mr. Rowley, we are glad to see you, because you are the new head of Titanium Corp., which corporation has a 10-ton-per-day contract to produce titanium. You know the situation and you know something about the hearings of this committee, and what we are trying to do.

You have heard the testimony this morning as to our needs. You know what we are producing. The whole picture does not look very good. We had a 2 day hearing in Henderson. We heard your organization there. Its history and its present production do not look very encouraging. You are new in this business. We called you this morning because you are newly appointed. We would like to have you identify yourself for the committee, and give us some of your background.

This, I understand, is not the first problem you ever tackled. I will say to you, as I did the Secretary of the Air Force, Mr. Talbott, this committee wants to help you. We want to be able to report to the Senate exactly the importance of each materials, and where we are getting the raw materials and what preparation is being made.

Will you go ahead now?

STATEMENT OF E. R. ROWLEY, PRESIDENT, TITANIUM METALS CORP. OF AMERICA

Mr. ROWLEY. Thank you, Mr. Chairman. My name is E. R. Rowley, president of Titanium Metals Corp. of America.

I would like to give you a little background on that company. It is jointly owned by Allegheny Ludlum Steel and National Lead Co. It was formed to produce titanium metal. It is an integrated producer. It makes sponge from ore at Henderson, melts it into ingot, either alloyed or unalloyed ingot at Henderson and sends those ingots to various Allegheny steel mills where it is fabricated for the Titanium Metals Corp. into what are called mill products, wire, rod, etc.

Those metal products are then sold by TMCA to aircraft engine or frame manufacturers at present.

The two companies have had a great deal of experience in the metallurgical and chemical field. Allegheny Ludlum, I think you know, is one of the major producers of stainless and specialty steels. National Lead Co. produces a variety of metals and chemicals, among them titanium dioxide, titanium pigments and from that sprang the interest in titanium metal.

We have a contract to produce 3,500 tons per year of titanium sponge. We started from some pilot-plant information. We are now producing on the order of 3½ to 4 tons per day. I think that has been in the testimony before, Mr. Chairman.

We have quality problems.

Senator MALONE. When were you supposed to reach your full production under your contract?

Mr. ROWLEY. The contract called for reaching full production on September 1, 1952. That was an optimistic appraisal, and we have had more difficulty in getting from the small to the large stage than we had anticipated, and that has been further complicated by the fact that the requirements for quality have been drastically increased since that time. Our original contract called for Brinell of 224. That is our major problem, as you know, the Brinell hardness of the sponge.

Senator MALONE. You found later, that hardness did not meet the required specifications of industry.

Mr. ROWLEY. That is right. It is difficult to make the high performance alloys that are now required.

At that time it was thought 224 was plenty good. Now it is not, and our problem is to make it much better than we had originally contracted. We can make very sizable quantities of material of the contractual Brinell hardness, but that is not what is wanted today. So the signals have changed as the game went along. As I say, we could turn out a very sizable tonnage of 224 Brinnel material right today.

Senator MALONE. Uniform material of Brinell hardness 224 as originally called for under the specifications of the General Services Administration.

Mr. ROWLEY. Yes, I think at the time those specifications were written, they were considered quite realistic in view of the knowledge available at that time. Now it has advanced considerably since then. Our problem is to make it much lower Brinell than that.

Senator MALONE. Do you know now what is required, approximately?

Mr. ROWLEY. Generally a fair share of the production should be of the order of 140 Brinell, with the balance perhaps somewhere of the order of 160, and not to exceed 180.

Senator MALONE. I think the Du Pont Corp. testified that they were making 140 Brinell. I could be wrong. It was in that neighborhood.

Mr. ROWLEY. Some of their production I understand is in that range. How much I do not know.

Senator MALONE. Go ahead.

Mr. ROWLEY. Our goal, and we are now spending a considerable amount of effort and money, is to get these lower Brinells that are required. As we get them, then we can develop alloys, and the Air Force can use those alloys and design around them.

Senator MALONE. When do you feel you will reach your full production of 10 tons per day with the required Brinell hardness?

Mr. ROWLEY. I believe it will be in the third quarter of 1954.

Senator MALONE. About 9 months away.

Mr. ROWLEY. About that. Perhaps sooner, but we would like not to be optimistic.

INCREASED PRODUCTION PLANS

Senator MALONE. Have you given any thought to the future in the titanium industry? Evidence before this committee shows the potential demand will be so much greater than any requirement set down by any government organization so that the committee is interested to know what preparations are being made, if any, to increase production beyond any existing contract.

Mr. ROWLEY. Mr. Chairman, we, of course, have given thought to that. We have unlimited confidence in the future of titanium metal as a structural material for both the near and the far future. I do not think we would be in it at all if we did not have that confidence. We have other things we could do.

A study of the record of both companies would indicate we have been rather interested in expansion. We would like to think that we would be a candidate for expansion. We would also like to lick some present problems, too.

Senator MALONE. You have no doubt in your own mind that you are going to lick these problems. Now that you are president of the company, you have full authority, I presume, to make any improvements you see fit?

Mr. ROWLEY. Subject to a board of directors, but in general that is correct. I have no doubt at all we can lick this problem. We have licked others equally tough. We made magnesium pretty successfully. We are making uranium pretty successfully right now for the Atomic Energy Commission. And we make nickel, we make lead, zinc, tin, aluminum, brass, stainless steels, silicon steels. I am talking about the combination of the companies now. We have made a lot of metals.

Senator MALONE. You met some troublesome problems but if the incentive was present you have always come out on top?

Mr. ROWLEY. That is right, and the incentive is there.

Senator MALONE. You speak of uranium materials. You are aware, I suppose, that we are dependent now on the Belgian Congo principally. Testimony before this committee in Salt Lake City showed—I cannot say showed conclusively, because the companies have not been turned loose—but the testimony showed if we treated our domestic companies one tenth as well taxwise as we do the ones operating in foreign nations in the production of these materials we buy, that domestic and Canadian uranium ore would probably be running out of their ears, within the next 4 or 5 years. But our producers are now in a position that the largest producers were not producing after the early part of the year, because if they produced more they would get in another tax bracket, and produce less for their stockholders. So on the one hand we prevent production in the United States and Canada and surrounding areas in the Western Hemisphere, and encourage production across the major oceans.

You heard the recommendation of Harry Dexter White that we do just that for the next two generations. That was in 1945. You heard what Mr. Truman thought about it in a letter dated July 23, 1946. Apparently we are continuing in our administration to carry out the same proposition. We encourage foreign production and are becoming more and more dependent on foreign shores. Where do you get your raw material?

Mr. ROWLEY. The present source of raw material is rutile from Australia.

Senator MALONE. Have you made any investigations as to the availability of the ilmenite material for titanium in this country?

Mr. ROWLEY. Yes, Mr. Chairman. The National Lead Co., I think, is the largest user of titanium in the world, and as such, of course, it has had its finger on the sources of raw material. It mines ilmenite in New York State in the Adirondacks. It gets some from the Florida beach sands and old beach deposits and imports some also. It is constantly working on sources of ilmenite.

Senator MALONE. Are you aware of the large deposits in nearby areas in Canada that are being worked?

Mr. ROWLEY. Yes, we are.

Senator MALONE. What is your opinion since you have gone into this matter far enough as to the dependability of the supply in this Nation and Canada and possibly Mexico, if properly developed?

Mr. ROWLEY. It is my understanding that there is sufficient ilmenite in the Western Hemisphere, as you outline it ,and beyond that in some of the Western States there are sizable deposits, too, to take care of certainly any titanium metal industry with a lot left over to take care of the titanium pigment industry, and probably enough for both.

Senator MALONE. You are familiar with the Kennecott operation in nearby areas in Canada?

Mr. ROWLEY. Yes.

Senator MALONE. The testimony they offered here is that 300 million tons of ore are already proven.

Mr. ROWLEY. I understand it is one of the largest ore bodies ever discovered.

Senator MALONE. To put the question another way, if you are in the manufacture of this material seriously, you know the contract was probably let to you because of the preparation for war; do you not?

Mr. ROWLEY. Yes.

Senator MALONE. Probably the only reason the Government would put up $15 million to you or $14,200,000 to the du Pont Co. would be because it is an emergency preparation.

Mr. ROWLEY. Yes.

Senator MALONE. Do you think you are very well prepared for an emergency if you are getting your raw material across a major ocean?

Mr. ROWLEY. I think we would need to shift to another source of raw material, which I believe could be put into production in a very short length of time.

Senator MALONE. You think you are practically prepared to do that now?

Mr. ROWLEY. Not economically, but we can do it. Our work is and will be toward the aim of assuring ourselves an economic Western Hemisphere source of supply.

Senator MALONE. Do you think it would be cheaper to bring it from India or Australia across 5,000 miles of ocean? What is the reason it is so cheap? On account of the low-cost labor in those countries?

WHY RUTILE?

Mr. ROWLEY. I presume that must have some bearing. The reason we are using rutile now—rutile is not as prevalent by any means

as these other ores we have been talking about—is that it is an easier starting material. There is a rough process. This is a tough metal to make. That is one reason it costs $5 a pound in sponge form. It was our idea to start from a relatively easy raw material and work back as we licked these other problems toward other starting materials. That is the reason for rutile.

Senator MALONE. You mean the rutile is easier to work with or you are just more familiar with it?

Mr. ROWLEY. It is easier to work with now. That does not mean it will be later.

Senator MALONE. Testimony has shown here that there is ilmenite slag with 70 percent content manufactured by the Kennecott Co. in nearby areas in Canada, and a large percentage of pig iron. In other words, they have two products, but they are separated. You tell me now that it is a more expensive process to use this ilmenite in slag form than it is to use rutile?

Mr. ROWLEY. I am not sure about the matter of expense, Mr. Chairman. I do know that slag contains approximately 70 percent TiO_2. A good natural concentrated rutile will run of the order of 92 to 95 percent.

Senator MALONE. The TiO_2 is titanium oxide?

Mr. ROWLEY. Yes. In one case you are working with a raw material of 70 percent of what you want to start with and in the other case something of the order of 95 percent.

Senator MALONE. Both high grade.

Mr. ROWLEY. Yes. In one case 30 percent extraneous material, and the other 5. So you have six times more extraneous material. That is the only reason for starting with rutile.

Senator MALONE. You do have in mind switching to domestic materials?

Mr. ROWLEY. Yes; we would hope we can.

Senator MALONE. Domestic meaning adjacent nations as well as our own.

Mr. ROWLEY. Yes.

Senator MALONE. You do not believe this theory of Mr. White and Mr. Truman that we should become dependent on foreign nations for materials without which you cannot fight a war?

Mr. ROWLEY. I do not think it would be very wise to do so.

Senator MALONE. Do you have any further general statement you would like to make?

Mr. ROWLEY. I think not, Mr. Chairman, if that gives you the information you would like.

Senator MALONE. I think it does. As I understand you, you are new on the job. When did you take over?

Mr. ROWLEY. September 24.

Senator MALONE. Then you really are new. You do intend to give this your whole attention.

Mr. ROWLEY. It is my full-time job and then some.

Senator MALONE. Generally an engineer's full-time job involves about 18 or 20 hours out of a day.

Mr. ROWLEY. Yes, sir.

Senator MALONE. The committee appreciates very much your appearance here this morning, and to know there have been some changes in the ideas of the company. I say that because 2½ years is a long time. While you are only responsible for one segment,

that is an important segment. There has been a contract recently let, with which you no doubt are familiar, for about 15 or 16 tons per day to Cramet, which is a Crane Co. subsidiary. They are now locating in Tennessee but their actual production will not begin until some time in the future. You have heard the testimony, or at least you have heard some of the comments on the testimony as to the requirements for this material. What is your idea of the use in the civilian market if this material of the right quantity and quality were available so they could go ahead with the same assurance they do with aluminum and steel now.

Mr. ROWLEY. I am afraid I am not qualified to give any such estimate now, Mr. Chairman. It unquestionably has long term commercial possibilities. It is corrosion resistant, as we all know, practically untouched by sea water. Therefore you have a great field there. Chemically it withstands many reactions. Actually we are using it in one of our own operations. It is pretty expensive, but as time goes on the cost will come down, and there are some reactions today, talking about uranium, I know one reaction that is carried out in a silver reactor. Titanium is not as costly as silver. There will be places for it at this cost and then as the costs come down, there will be more. Fifty dollars a pound aluminum was pretty expensive. That was pig form. That is compared to $5 a pound sponge titanium 3 years after its commercial application.

Senator MALONE. In the 1953 dollar.

Mr. ROWLEY. Yes. We have been producing a little more than anybody else in the country today, and we would like to think some day we will stay ahead of the other fellows.

Senator MALONE. You have other problems in your area. One of them is power. I am not going to ask you any questions this morning on power, but I may later.

We appreciate very much your appearance here, Mr. Rowley.

Mr. ROWLEY. Thank you.

Senator MALONE. It is encouraging to know that the company is reorganizing its affairs and making good on the contract.

Mr. ROWLEY. Thank you.

Senator MALONE. Mr. Garrett, of the Air Force requirements Division.

As I recall you were a good witness. We are calling you for any further information you may have to offer with respect to the requirements of the Air Force, how these requirements are determined, and any other material that you would like to submit.

FURTHER STATEMENT OF JOHN H. GARRETT, EXECUTIVE DIRECTOR OF MATERIALS COMMITTEE, OFFICE OF ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND DEVELOPMENT; ACCOMPANIED BY NATHANIEL FICK, DIRECTOR OF PANEL ON METALS AND MINERALS, OFFICE OF ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND DEVELOPMENT, WASHINGTON, D. C.

Mr. GARRETT. Should I identify myself?

Senator MALONE. Yes.

Mr. GARRETT. My name is John H. Garrett. I am executive director of the Committee on Materials of the Office of Assistant Secretary of Defense for Research and Development.

When I was here Monday I had supposed that you would be asking me about the research and development program, and I did not brief myself ahead of time on the origin of the 35,000-ton requirement. I did not have my file with me on that particular subject. I have since at your request looked into that. I would like to prepare the background of this thing by going back about a year and a half to look at our situation at that time.

We had a newly established Committee on Materials at that time in the Research and Development Board, which was the predecessor organization of the present Office of Assistant Secretary of Defense for Research and Development. One of the prime concerns of the newly formed committee was the titanium situation. I think titanium was on the agenda for every meeting held by that committee.

At that time, in the spring of 1951, we had not made nearly the progress on titanium we have now. There was no titanium in any production item. I think I am correct in saying that at that time. It was purely in the experimental stage. We did not know how to make it and we did not know how to fabricate it or use it in military equipment.

Nevertheless, our committee was fully cognizant of the promise of titanium. We had confidence in the research and development organizations of the Department, and we were sure that they would overcome the handicaps of titanium and its promise would be fulfilled.

The problem seemed to be how to overcome the processing difficulties of the manufacturers in making titanium in adequate uniform quality.

After much necessary consideration, the committee considered the only way to find out how to make titanium was to go ahead and make it in quantity. We therefore requested the Munitions Board, which was the predecessor of the present Office of Assistant Secretary of Defense for Supply and Logistics, to ascertain from the Army, Navy, and Air Force what their requirements for titanium would be 3 years from then in terms of the present price.

The Munitions Board got their figures from the Army, Navy, and Air Force, and they added up to approximately this 35,000-ton figure that has been mentioned before.

95 PERCENT FOR AIR POWER

You asked me to find out where those figures came from, and it is my understanding that something over 95 percent of that requirement of 35,000 tons was an aeronautical requirement.

Senator MALONE. What percentage?

Mr. GARRETT. Something over 95 percent of the 35,000 tons at $15 a pound. That was one of the provisions we put on it, because we did not foresee that the price would come down substantially in the early stages.

Senator MALONE. Let me ask you right there, what are you in this committee? Are you on this committee?

Mr. GARRETT. I was the executive director, the head of the staff of this committee.

Senator MALONE. You are telling me that the price would not prevent you from using it?

Mr. GARRETT. No, sir. We felt that we should not count on a reduction in price during the first few years of titanium production.

Senator MALONE. But I understand you to say that you limited your recommendations on account of the price.

Mr. GARRETT. You understand, sir, that we were looking only 3 years ahead at this time.

Senator MALONE. Any amount ahead.

Mr. GARRETT. Had we looked farther ahead when production was higher, we would suppose that the price would gradually go down.

Senator MALONE. Suppose it does not come down. Are you going to stop using it?

Mr. GARRETT. It will be limited to less use at the present price than at a lower price.

Senator MALONE. In the war planes?

Mr. GARRETT. Not in the war planes.

Senator MALONE. That is what you are concerned with?

Mr. GARRETT. We are concerned with all military equipment, including ships, tanks.

Senator MALONE. You have heard the testimony on the planes that they could use about 50 times what they are now actually getting, and use many, many times what you have contracted for, and even what you requested. The makers of the planes and the general in charge of that particular setup at Wright Field have so testified. Did you consult anyone like General Metzger at Wright Field?

Mr. GARRETT. I was going into that, sir.

Senator MALONE. Are you still telling me that you would cut down the use of titanium where it made more efficient fighting equipment if the price was not reduced?

Mr. GARRETT. In some applications I am sure it would, such as naval ships.

Senator MALONE. You mean this 35,000 tons included naval ships?

Mr. GARRETT. It included the Navy statement of what they would require at that price, because that was the current price.

Senator MALONE. Do you suppose they come as close as the Air Force did?

Mr. GARRETT. I think, sir, if the testimony is analyzed it will show that we were pretty close to the right figure for that date. I would like to say a little more about that in a few minutes, if I might.

Senator MALONE. I wanted to ask you, what are you recommending now, or is your committee still functioning?

Mr. GARRETT. I should like to make it clear that our committee is not primarily responsible for requirements, and that is why we went to the Munitions Board and asked them what the requirements were.

Senator MALONE. What do you think that the requirements are now after hearing the testimony?

Mr. GARRETT. I think the requirements for 1955 would come pretty close to this 35,000 tons, and be much higher in subsequent years.

Senator MALONE. Are you familiar with the testimony that they could use much more than the 35,000 today if they knew they could have it?

Mr. GARRETT. Yes, sir. You gave me that testimony and I read every word of it that night, and I find myself in full agreement with it.

Senator MALONE. If you are in full agreement with it, 35,000 tons was not even within a fifth of what they need by 1956 and 1957, if they

know they will have it prior to that date so they can take the plans off the board and get started.

Mr. GARRETT. I took the liberty of drawing a little sketch, Senator, to show what I feel the titanium situation is productionwise.

Senator MALONE. What does this represent?

Mr. GARRETT. Tons of titanium with no figures put on it because I do not know the figures. This represents 1955 which was the date when we asked for requirements.

Senator MALONE. You asked for 35,000 tons for 1955.

Mr. GARRETT. I feel that this is a point on a rising curve, and that the testimony of the aircraft people brought out is farther up the curve.

RATIONING EVILS

Senator MALONE. What I would say to you is that for 20 years we have had an administration that always wanted to ration all of the materials, so they worked it out somehow so that they could have somebody like you saying so much will be used here, and so much will be used there, and finally they would just run out of it. They would never have as much as they needed when the time came. That applies to manganese, it applies to tungsten, it applies now to titanium. When you start rationing a thing, you always run out of the material because you scare everybody out of the business. Only Government money is available to an industry when you start rationing.

I thought you were saying that you were correct in estimating the production. Now, you do modify your statement so that the curve is away above.

Mr. GARRETT. Yes, sir. I meant only to say that this was a point during the early years of a rapidly increasing production rate.

Senator MALONE. What do you do after you make estimates like you did 3 years ago? Do you go to sleep for 3 years, or do you keep up with it?

Mr. GARRETT. Sir, if I might read this memorandum, it shows exactly what we did with it. I think it is important to have this in the record.

Senator MALONE. I know what you have done with it. That memorandum may show what you intended to do about it.

Mr. GARRETT. This is a memorandum for the Chairman of the Munitions Board.

Senator MALONE. What date?

Mr. GARRETT. The date is July 28, 1952. It is a memorandum for the Chairman of the Munitions Board, which is now the Office of the Assistant Secretary of Defense for Supply and Logistics. The organization has been streamlined this past summer.

Senator MALONE. I have heard so much about streamlining of organizations. Why do you not abolish some of them? You do not need anything but the recommendations from the National Defense organization. I want to know now where the Defense recommendations go. Where does it go, if you know? Does it go back to one of these trick committees that you have?

Mr. GARRETT. No, sir. I was trying to make it clear that the Army, Navy, and Air Force originated this 35,000-ton figure.

Senator MALONE. That is right. Where did it go?

Mr. GARRETT. Of that, 95 percent was Air Force and Navy aeronautical requirement, and that part of it, that 95 percent or greater

figure came from the Aircraft Production Resources Administration at Wright Field.

Senator MALONE. We had testimony awhile ago that they recommended 28,000 tons, which was most of it. Where did that 35,000 tons recommendation go?

Mr. GARRETT. Shall I read this for the record now, because this shows the first stage, and I am trying to take it along step by step to show chronologically where it did go.

Senator MALONE. What is the end of it? Does it show where it goes?

Mr. GARRETT. This memorandum shows where it came from and where it went at this step.

Senator MALONE. I know where it comes from? It comes from the National Defense Secretary.

Mr. GARRETT. That is right.

Senator MALONE. Where does it go from the National Defense Secretary? Does the memo show?

Mr. GARRETT. The memo does not show that.

Senator MALONE. Then there is no use for the memorandum at all. Do you know where it goes?

Mr. GARRETT. I know where this recommendation went.

Senator MALONE. Where did it go?

Mr. GARRETT. It went from the Munitions Board to the Defense Production Administration, which is outside the Department of Defense.

Senator MALONE. What date did the 35,000-ton requisition go there? What date was it made, and when did it go there?

Mr. GARRETT. The date was July 28, 1952, and it is my understanding that it went to DPA on August 3.

Senator MALONE. That is what?

Mr. GARRETT. Defense Production Administration.

Senator MALONE. Who is head of that?

Mr. GARRETT. That is now consolidated with the Office of Defense Mobilization.

Senator MALONE. Who is the head of it now?

Mr. GARRETT. Dr. Flemming is now the head of it.

Senator MALONE. And that is the ultimate authority?

Mr. GARRETT. The ultimate authority.

Senator MALONE. And was it at that time?

Mr. GARRETT. It was at that time.

I can only say that they were at the 22,000 tons and they put the year back 1 year from 1955 to 1956.

Senator MALONE. I would say that they put it ahead.

Mr. GARRETT. Our recommendation was for 35,000 tons in 1955, and the goal established was 22,000 tons in 1956.

Senator MALONE. Now, who are the members of that committee? Do you know?

Mr. GARRETT. Which committee, sir? The Office of Defense Mobilization? That is not a committee.

Senator MALONE. What is it?

Mr. GARRETT. It is a staff organization of the staff of the President.

Senator MALONE. Who are the members?

Mr. GARRETT. Dr. Flemming is the head, and who there is in it below that, I don't know.

Senator MALONE. Does it include any Cabinet officers?

Mr. GARRETT. I think not, sir.

Senator MALONE. And it is a new committee, sort of a blind committee, as far as you know?

Mr. GARRETT. It is not exactly a committee. It is an organization on the staff of the President, that handles all mobilization matters for him.

Senator MALONE. All right. Then they cut it to 22,000, which would mean about 18,000 for the Air Force in all of its ramifications?

Mr. GARRETT. Yes, sir.

Senator MALONE. Do you think, in view of what has developed here, that that is enough?

Mr. GARRETT. I do not, sir. We have been much concerned that our recommendation of 35,000 tons for 1955 was reduced to 22,000 tons for 1956. We have never thought that was the right thing to do.

Senator MALONE. Let me ask you one more question. Have you at any time since you recommended it, reviewed the 35,000 tons?

Mr. GARRETT. We made the recommendation to the Munitions Board, which is responsible in that area, that they review it at frequent intervals.

Senator MALONE. Are they responsible now?

Mr. GARRETT. The successor is.

Senator MALONE. Who is the successor?

Mr. GARRETT. The Assistant Secretary of Defense for Supply and Logistics.

Senator MALONE. Then the Munitions Board has nothing to do with it? Is that true?

Mr. GARRETT. There is no Munitions Board any more.

Senator MALONE. Let us just forget those who are out of it, now. What I want to know: Has this committee of yours, or whatever it is, made any estimates since June or July 1952?

Mr. GARRETT. We have kept up with the research and development picture on titanium, Senator. But my committee was stepping a little bit out of line, actually, outside of their responsibilities, in getting into this quantitative requirements picture at all. Because that is a responsibility assigned to the other organization.

Senator MALONE. What is that organization?

Mr. GARRETT. The Supply and Logistics Assistant Secretary.

Senator MALONE. And that is the Assistant Secretary of National Defense?

Mr. GARRETT. Yes. We are Assistant Secretary for Research and Development. They are a parallel organization for supply and logistics, and they are responsible for production and requirements and that sort of thing.

Senator MALONE. My question should be directed to the other Assistant Secretary, I guess. To whom is he Assistant.

Mr. GARRETT. To Mr. Wilson, Secretary of Defense.

Senator MALONE. And their recommendations to Mr. Wilson are supposed to embody the recommendations of the Air Corps, the Army, and the Navy?

Mr. GARRETT. That is correct.

Senator MALONE. And that is the last word at the present time?

Mr. GARRETT. That is correct.

Senator MALONE. When did that occur, that consolidation? How long ago were they made actually responsible?

Mr. GARRETT. Let me see if I understand. You mean when the departments were consolidated under the Department of Defense?

Senator MALONE. Yes, sir. When the Munitions Board was out of it.

Mr. GARRETT. That was abolished on June 30 of this year and replaced by the Assistant Secretary of Defense for Supply and Logistics.

Senator MALONE. Then the Assistant Secretary of Defense has only been really responsible for it since July of this year?

Mr. GARRETT. That is correct.

Senator MALONE. They are now?

Mr. GARRETT. That is correct.

Senator MALONE. Do they have anything underway to determine what they need?

Mr. GARRETT. I cannot tell you, but I think there are witnesses here who can from that office.

Senator MALONE. Well, I only had in mind that apparently, if you were right 2 years ago as to the demand, somebody was derelict in not following through. Because the demand was there ahead of you. I mean, it has no connection with what you recommend at all. And then apparently what this Board of the Defense Mobilization Administration recommended had no connection whatever with what the Secretary of National Defense had recommended. The recommendation was not quite cut in two, but the cut was pretty close to that amount.

Mr. GARRETT. Not only cut in two, but put the year farther away than what we had recommended, which I think is also significant, in view of this curve. In 1946 our recommendation would not have been 35,000 tons but would have been up here somewhere.

Senator MALONE. The significant thing to the chairman of this committee is that the whole program has been set back 2 or 3 years, and that was the only thing that happened. You heard the Secretary testify this morning. You can get right on the job and see if this program cannot be accelerated, and I think you will.

I guess this is not the kind of question to ask you, but I would like to ask somebody, if they know, why this matter had not been brought to the Secretary's attention before now.

Mr. GARRETT. That, of course, is nothing I could answer. That, of course, is within his own Department.

Senator MALONE. Well, I think that is clear enough: that you made this recommendation of 35,000 tons a year in 1952. In June, was it?

Mr. GARRETT. In July.

Senator MALONE. In July 1952. And there has been no subsequent recommendation. That is true, is it not?

Mr. GARRETT. I can't answer that, because a subsequent recommendation would have come from the other office, the Munitions Board.

Senator MALONE. It generally gets in the newspapers, does it not?

Mr. GARRETT. It is my understanding that they did set up a body to review the requirements for titanium, but I am not familiar with the details of that body.

Senator MALONE. Apparently we have 40 or 50 bodies reviewing it. It seems that is about all you do over there.

I appreciate your coming back and, as you say, this increase in production is not in your field. Your field consists of keeping abreast and trying to accelerate the development of a proper quality of titanium.

We will save these questions for Mr. Rolle, then. I think he is here.

What is your opinion after hearing the testimony, maybe you knew before, as to the possibilities of lower cost production and of different processes coming in and becoming feasible? Could you give us any statement that you might care to make in that particular field, as to quality and production that may come from either newer processes or improvements of the Kroll process?

SAYS KROLL PROCESS INEFFICIENT

Mr. GARRETT. It has been recognized by us from the beginning that the Kroll process was an inefficient process and would not ultimately be the process that is to be used for major production of titanium.

Senator MALONE. You agree with Union Carbide, then, apparently, and their subsidiary, that it would not ultimately be the process? And therefore they severed connections with Mr. Kroll?

Mr. GARRETT. Yes. But in spite of the fact that we, you might say, were sure that the Kroll process was not the ultimate process, we did recommend this initial expansion using the Kroll process, knowing it would be obsolete, because we were satisfied that we had to have titanium in our equipment.

Senator MALONE. I think that was entirely justified. There also was justified including in the contracts an obsolescence paragraph, that the payment of the cost of such equipment made obsolete by improvements would be undertaken by the Government. I think that was very fair, on account of the emergency we were in as regards production.

Do you have anything else to offer?

Mr. GARRETT. I have one more thing here to complete the story of what we did at that time, if you would like to have it. It is part of this same action we took in the spring of 1952.

Senator MALONE. Describe it.

Mr. GARRETT. As I say, there was no titanium in production of any military equipment at that time. It was all experimental. The orders that were being placed on the manufacturers were very low. They came to us and said, "Nobody is buying our titanium. What can we do?"

So we wrote this memorandum for the departments of the Army, Navy, and Air Force, subject: "Utilization of Titanium."

Use of titanium in a wide variety of military equipment shows promise of providing markedly improved performance through reduction in weight and improved corrosion resistance. It would also reduce requirements for certain critical metals. It is, therefore, important that titanium be incorporated in new designs wherever improved military performance justifies—

Senator MALONE. I think it would save your time and that of the committee if you would like to incorporate it in the record.

Mr. GARRETT. I would be glad to leave that, Senator.

Would you like to have this memorandum also?

Senator MALONE. We will have these two memorandums presented for the record at this time as a part of the testimony of Mr. Garrett.

(The documents referred to are as follows:)

RESEARCH AND DEVELOPMENT BOARD,
Washington 25, D. C., August 7, 1952.

Memorandum for Department of the Army: Deputy Assistant Chief of Staff, G–4, for R. & D.
Department of the Navy: Chief of Naval Operations (O$_p$–372).
Department of the Air Force: Deputy Chief of Staff, Development.
Subject: Utilization of Titanium.

Use of titanium in a wide variety of military equipment show promise of providing markedly improved performance through reduction in weight and improved corrosion resistance. It would also reduce requirements for certain critical metals. It is, therefore, important that titanium be incorporated in new designs wherever improved military performance justifies the increased cost.

Two major obstacles have been preventing widespread use of titanium—high cost and lack of assurance of availability in the quantity and quality required. Studies indicate that the high price and uncertain quality of titanium alloys now being produced are to a large extent due to the small tonnages handled and lack of experience in controlling production processes. It is believed that the only way these obstacles can be quickly overcome is to produce titanium in larger quantities, thus reducing high overhead and scrap losses and providing the producers the opportunity, through experience, to develop controls and skills necessary for uniformity of product. Steps are being taken by the Munitions Board and Defense Materials Procurement Agency to provide a rapid increase of production to 35,000 tons per year within 3 years. We have been informed by the Munitions Board that this is the quantity the departments have indicated can be used at current prices. This expansion of titanium capacity will be practicable only if the demand is in balance with the increasing production.

With these considerations in view the Research and Development Board's Committee on Materials adopted the following resolution at its last meeting on July 23:

"It is recommended that the Department of Defense take action to utilize all available titanium in applications where military advantages are dominant."

We are calling this action of the committee to the attention of the three Departments and we strongly urge each to take steps to assure the utilization of available titanium as recommended by the committee.

FLOYD L. MILLER, *Vice Chairman.*

RESEARCH AND DEVELOPMENT BOARD,
Washington 25, D. C. July 28, 1952.

Memorandum for Chairman, Munitions Board.
Subject: Recommendation Concerning Titanium.

1. The Research and Development Board, as I believe you know, has been greatly interested in the metal titanium and in assuring that the research efforts on methods for its recovery are consistent with the importance of the metal to the defense effort. The Committee on Materials of the Board has been particularly interested in this problem and has devoted a great deal of attention to it.

2. At its last meeting on July 23, 1952, the Committee on Materials adopted two resolutions which I am forwarding to you since I believe they are of prime interest to the Munitions Board:

1. Inasmuch as the military requirements 3 years hence for titanium sponge, at present cost, have been determined by the Department of Defense to be 35,000 tons per year, it is recommended that the appropriate Government agencies take action to make a capacity of 35,000 tons per year available within 3 years.

2. It is recommended that in view of the fact that the price of titanium is expected to be reduced with increased production and technological improvements, military requirements for titanium be reappraised at frequent intervals.

These were largely promoted by the feelings of the committee members that early use of titanium in the design and production of military end item will continue to lag unless there is some assurance that the metal will be available as needed.

3. There may be some question as to whether the two resolutions are within the province of the Committee on Materials. However, in addition to the RDB representatives and members from the three services, there were in attendance at the meeting responsible representatives from MB, DMPA, ODM, and MMAB, who participated in the framing of the resolutions. The recommendations, therefore, represent the considered views of a large group of individuals of competence in this field.

4. I am, therefore, passing the resolutions on to your for your consideration and for any possible action you may desire to take.

FLOYD L. MILLER,
Vice Chairman.

Senator MALONE. We were glad to hear from you, Mr. Garrett, and if there is any new material that comes to your desk that you think will be valuable to us in our work, you know we would be glad to receive it.

Mr. GARRETT. Thank you very much.

Senator MALONE. Mr. Carl Rolle?

Mr. Rolle is with the Office of the Assistant Secretary of Defense for Logistics, formerly associated with the Munitions Board. Of course, the Munitions Board is no longer in existence.

Mr. Rolle, you heard or reviewed a considerable amount of the testimony.

Do you have anything further you can offer to the committee this morning?

STATEMENT OF CARL ROLLE, ASSISTANT STAFF DIRECTOR FOR PRODUCTION AND SCHEDULE, OFFICE OF ASSISTANT SECRETARY OF DEFENSE (SUPPLY AND LOGISTICS); ACCOMPANIED BY DR. TIMOTHY C. MAY AND JOSEPH ROMM, OFFICE OF ASSISTANT SECRETARY OF DEFENSE (SUPPLY AND LOGISTICS)

Mr. ROLLE. I believe I might be able to clarify some of the chronology of these requirements submissions, inasmuch as prior to June 30, the Munitions Board was responsible, in the Department of Defense, for such activity.

Senator MALONE. June 30, 1953?

Mr. ROLLE. Yes, sir. I was on the staff of the Munitions Board during that period.

Since June 30, those functions have been assumed by the Assistant Secretary of Defense (Supply and Logistics).

Senator MALONE. How was that reorganized? Was it reorganized under a general order reorganizing other departments also?

Mr. ROLLE. No, sir. It was Reorganization Plan No. 6, which did several things, if I may review it.

It abolished the Munitions Board and the Research and Development Board.

Senator MALONE. That was the organization as headed by Mr. Flemming?

Mr. ROLLE. Yes, sir. He became the first head of the permanent ODM.

Senator MALONE. What was his position before that Board was charged with this responsibility?

Mr. ROLLE. His position personnally, sir?

Senator MALONE. Yes.

Mr. ROLLE. I am not too familiar with that.

Senator MALONE. Go ahead, then.

Mr. ROLLE. I would prefer not to be quoted. The matter of titanium had been under considerable discussion in late 1951 or early 1952, starting as a research and development matter, as Mr. Garrett has testified, inasmuch as it was an entirely new field of material for military use, military and other use.

STRONG INTEREST EXPRESSED

If the Senator will permit, I may want to consult with Dr. May or Mr. Romm from time to time, and get my figures straight.

On January 10, 1952, the Acting Chairman of the Munitions Board, Mr. Houston, addressed a letter to Mr. Charles E. Wilson, who was then Director of the Office of Defense Mobilization. I explained, of course, that that was not the Charles E. Wilson who is now Secretary of Defense. The general interest of the Military in this new material was there strongly expressed. No numerical requirement, however, was given, because we were at that time beginning to get into a study of those requirements. I simply bring to the committee's attention the fact that at that time we simply indicated our strong interest in it. We reviewed to the ODM the present, or what was then the present, production level, and what production levels were then being projected by the producing industries.

We then, in a gradual transition from the research and development type of discussion, which Mr. Garrett has related, went into the function which we then performed, that of determining from the three military departments, under the Department of Defense, their best reasonable and justifiable estimates of what their requirements might be.

At that time, we formally asked them to submit requirements for approved and projected uses through the year 1954. We later amended that and asked them to try to look ahead through the year 1956.

As a result of the returns on that—and, of course, the Joint Aircraft Agency of the Air Force and the Navy accounted for the bulk of it—we addressed a letter of July 31, 1952, to the Defense Materials Procurement Agency, that being the predecessor of GSA in the materials expansion business, and recommended that steps be taken as early as possible to provide a capacity of 35,000 tons of titanium sponge.

There was a further letter, which might be considered a more formal claim for support. I believe it was August 3. I do not have a copy of it here. That was addressed to the Defense Production Administration, which agency's functions have since been taken over by Dr. Flemming.

As a result of that, the Defense Production Administration first established an expansion goal of 20,000 tons. This fact was announced to us in a letter of the 19th of September 1952.

(The letter referred to follows:)

SEPTEMBER 19, 1952.

MR. NATHANIEL KNOWLES, JR.,
Vice Chairman for Materials, Munitions Board,
Washington 25, D. C.

DEAR MR. KNOWLES: This is to advise you that the expansion goal for titanium is being reduced from 35,000 tons annually to 20,000 tons annually.

The reasons for this reduction are as follows:

(1) The Kroll process for making titanium sponge is extremely complex and uneconomical. With the amount of research that is currently being applied to this problem by the laboratories of some of the largest corporations of the United States, it is a good assumption that there will soon be a more economical process for making the sponge or a similar material and any plants erected with Government funds, using this present Kroll process, would become obsolete overnight. As you know, the estimated capital cost of new facilities to produce 27,500 tons of sponge over and above the present existing capacity of approximately 7,200 tons per year is $140 million.

(2) In calendar year 1952 the total cost of all materials, aluminum, steel, copper, rubber, etc., at current market prices used in the aircraft program will cost approximately $560 million. In the year 1955 the total annual capacity of titanium metal production will be something over 40 million pounds and the great majority of this metal is destined for the aircraft program. The average price for titanium products is $15 per pound. Thus, for 1 metal an expenditure of $600 million must be made for the military aircraft program which exceeds the total spent for all metals in 1952—the peak year for materials procurement for the present aircraft schedules.

(3) The consensus of opinion of all industry men in NPA who are familiar with this metal is that the goal of 20,000 tons is sufficient until more advanced technological knowledge is available concerning this metal.

(4) The staff of the DPA is also of the opinion that it will be necessary for the Government not only to finance the construction of the new titanium sponge plants but also to provide a guarantee-purchase program for all titanium sponge produced under this expansion plan. For this reason alone it is felt that the Government should proceed into this program on a more moderate basis than would be the case if a 35,000-ton goal were established.

This expansion goal of 20,000 tons will be reviewed within the next 6 months for possible further revision. If at that time the Department of Defense has more definite requirements than under its current submission and if the titanium metal then being produced is all being picked up by firm orders, I am sure an upward revision in this goal can be made without undue difficulty.

Sincerely yours,

W. N. LAWRENCE.
Director, Military and Atomic Energy Division.

SUMMARY SHEET—INFORMATION ON TITANIUM PRODUCTION REQUESTED DURING HEARINGS CONDUCTED BY THE MINERALS, MATERIALS, AND FUELS ECONOMIC SUBCOMMITTEE, SENATE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS

1. Question. What were the quantities of titanium originally recommended to the Department of Defense by the Army Navy, and Air Force?

Answer. The titanium requirements submitted by the services are—

	Tons
Army	800
Navy	3,000
Air Force	24,600
Total	28,400

A production goal of 35,000 tons was recommended by the Department of Defense to allow for additional potential military and essential civilian requirements.

2. Question. It is understood that the Department of Defense recommended 35,000 tons to the Office of Defense Mobilization. Why did the latter cut this recommendation to 22,000 tons?

Answer. The reasons given by the Office of Defense Mobilization for establishment of a reduced expansion goal are contained in a letter, dated September 19, 1952, addressed to the Vice Chairman for Materials, Munitions Board, from the Director, Military and Atomic Energy Division, Defense Production Administration. A copy of that letter is attached hereto.

3. Question. Who (what office, specifically) makes these recommendations to the Department of Defense? To the Office of Defense Mobilization? To the General Services Administration?

Answer. The military services submit requirements to the Department of Defense through offices as follows:

(*a*) Air Force: Office of the Assistant Secretary (Materiel).

(*b*) *Army*: Office of the Assistant Secretary (Materiel).

(*c*) Navy: Office of the Assistant Secretary

The Office of the Assistant Secretary of Defense (Supply and Logistics) submits consolidated requirements to the Office of Defense Mobilization. The Office of Defense Mobilization then certifies a program and authorizes the General Services Administration to proceed within the scope of the certification.

4. Question. Who follows through on the allocations and contracts involved to see that titanium production is satisfactorily accomplished?

Answer. The contracting agency, Emergency Procurement Service of the General Services Administration (successor to the Defense Materials Procurement Agency) follows through on contract.

Mr. ROLLE. Shortly thereafter—and I do not have the date available—that 20,000 tons was amended to 22,000 tons. We understood the principal reason was that in discussing with potential contractors the units that they might put into production, the 20,000 didn't happen to come out even with proposed production units, and it was adjusted to 22,000.

Mr. ROLLE. I am unable to answer that question, Senator.

Senator MALONE. That sounds as reasonable as a lot of things they did. They cut it because it did not fit in with some other plan that they had.

Mr. ROLLE. I believe that an expansion goal, using their terminology, is the setting of the target toward which building should be encouraged.

Senator MALONE. We hit the target with the national-defense recommendation. Upon what did they base the cut, do you know?

Mr. ROLLE. I honestly do not, sir, know why the number was cut.

Senator MALONE. Let me ask you, now. You were with the Board. What is your position now?

Mr. ROLLE. I am on the staff of the Assistant Secretary of Defense, Supply and Logistics.

Senator MALONE. Upon what, then, did your organization base its recommendation of 35,000 tons?

Mr. ROLLE. We based our recommendation of 1952 on the survey which we caused the military departments to make of their contractors and their designers and their sources of information.

Senator MALONE. Do you have the amounts recommended by each of the departments?

Mr. ROLLE. Actually, I believe the total projection through 1956 in terms of sponge amounted to 28,400 tons. We actually took the liberty and agreed——

Senator MALONE. How many thousand tons?

Mr. ROLLE. 28,400 tons. Of that amount, 24,600 was Air Force.

Senator MALONE. What date was this?

Mr. ROLLE. These were the returns which came to the Department of Defense some time in July, I believe. Those figures originally came to us in the summer of 1952, and were the basis of the request we sent.

Senator MALONE. Give me just briefly the amount of the recommendations made by the three branches of the service.

Mr. ROLLE. Air Force was 24,600.

Senator MALONE. I understood it was 28,000.

Mr. ROLLE. Excuse me. The Navy was down for 3,000. Now, most of that was for aircraft work.

Senator MALONE. What would it have been then as a total?

Mr. ROLLE. That would have been 27,600, of combined Air Force and Navy.

Senator MALONE. Did the Navy have any further recommendation?

Mr. ROLLE. We can look that up in detail.

Senator MALONE. Do you have a total some place for Air Force, Navy, and Army?

Mr. ROLLE. Yes, sir. The Navy total was 3,000 tons.

Senator MALONE. And the Air Force total?

Mr. ROLLE. Twenty-four thousand, six hundred.

Senator MALONE. How much for the Army?

Mr. ROLLE. Eight hundred tons.

Senator MALONE. What does that add up to?

Mr. ROLLE. Twenty-eight thousand, four hundred. And we actually submitted a recommendation that capacity be brought up to 35,000 tons by 1956; roughly a 25-percent markup.

Senator MALONE. Twenty-five percent more than the national Defense Departments recommended.

Mr. ROLLE. More than our constituents recommended to us.

Senator MALONE. That is right.

Mr. ROLLE. Of course, we were also thinking, Senator, in terms that if the material were available over and above military needs, there certainly would be counterpart civilian uses. And we were talking in terms of the national need.

Senator MALONE. So then you sent it to the War Mobilization Administration headed by Mr. Flemming, and they cut it to 22,500 tons?

Mr. ROLLE. First to 20,000, and then back up to 22,000. And if I may, with your permission, correct the record, Dr. Flemming was not the head of it at that time.

Senator MALONE. But it was the same Board?

Mr. ROLLE. It was the organization which he is now the successor to. It had substantially the same function.

Senator MALONE. The National Production Administration?

Mr. ROLLE. It was the Defense Production Administration.

Senator MALONE. Now, however, it has turned into what?

Mr. ROLLE. The Office of Defense Mobilization.

Senator MALONE. Has this Office of Defense Mobilization ever seen this recommendation?

Mr. ROLLE. Yes, sir, it has.

Senator MALONE. When?

Mr. ROLLE. Well, shortly after the Republican administration took office, which was January 20, I believe—and believe me, this is not meant to be critical in any way——

Senator MALONE. I understand.

PROGRAM RE-EXAMINED

Mr. ROLLE. Because they realized that there had been authorized under a previous administration many millions, even billions, of dol-

lars of Government commitments, and the like. And all of the materials expansion programs early in 1953 were frozen for reexamination. One of them was the titanium program.

There then followed a period of several months, in which the Office of Defense Mobilization asked the Department of Defense to reexamine and recertify its requirements, which we did.

And then, after considerable discussion and examination, the titanium expansion program was recertified. I haven't the precise date. The recertification, I think, came in August of 1953, at a level of 25,000 tons.

Senator MALONE. Let us just break loose from this business, now, of cutting of the estimate. We know it was done by a Board superseded by the Office of Defense Mobilization. Is that right?

Mr. ROLLE. Yes, sir. And I understand the presently existing expansion goal today is 25,000 tons.

Senator MALONE. It has been raised 3,000 tons?

Mr. ROLLE. Yes, sir.

Senator MALONE. Now, who is responsible then for securing this 25,000 tons?

CERTIFICATION PROCESS

Mr. ROLLE. My understanding—and it is not authoritative since it is not the function of my department—is that the expansion programs certified by the ODM, Office of Defense Mobilization, are then turned over to the General Services Administration for the finding of producers and the working out of whatever necessary contracts are involved. I believe the Office of Defense Mobilization, at least in major instances, also requires that the individual contract be resubmitted for certification.

Senator MALONE. Now, what do you mean "resubmitted"?

Mr. ROLLE. Well, for example, in the present instance, if the Office of Defense Mobilization certifies an expansion goal of 25,000 tons of titanium and General Services Administration works with the XYZ Corp. as a potential producer, before signing a contract with XYZ, my understanding is—and it is certainly subject to correction if I am wrong—that General Services must then take that proposition back to the Office of Defense Mobilization and get the actual project certified.

Senator MALONE. Get the approval?

Mr. ROLLE. Yes, sir.

Senator MALONE. Of that organization, of that particular contract?

Mr. ROLLE. Of that contract.

Senator MALONE. Well, some progress is being made here. Then, as far as national defense is concerned, three organizations are responsible for production. One is the National Defense organization for the original recommendation; next, the Office of Defense Mobilization to review that, raise it to anything they want, but when they get through they recommend that a definite amount of that material be secured?

Mr. ROLLE. That is my understanding.

Senator MALONE. Then it goes to the General Services Administration to make the actual contracts. Those contracts are individually returned to the Office of Defense Mobilization for approval. Assum-

ing that they are approved, then, they are to be cleared by the General Services Administration. Is that true?

Mr. ROLLE. That is true to the best of my knowledge.

Senator MALONE. Now, does your organization, the National Defense, any subsidiary or committee thereof, keep a check on the progress of the contracts, the progress of the manufacture or production, or the securing of this material?

Mr. ROLLE. Yes, sir. We conceive it to be our responsibility to, first, maintain contact with the Office of Defense Mobilization to see what is happening to any recommendations that we have sent over, furnish them any justifications.

Senator MALONE. Do you know just what had happened in the production of titanium?

Mr. ROLLE. Yes, sir.

Senator MALONE. What had you done about it?

Mr. ROLLE. I will try to tell you that, if I may.

When a program has been certified, we also maintain contact with General Services Administration or its predecessors in the field to keep informed, at least, as to what they are doing, with whom they are working, what the prospects look like. We do receive reports of what the monthly production actually is. We are not in a position, however, to in any way instruct General Services Administration as to what to do.

Senator MALONE. That is the prerogative of the Office of Defense Mobilization? They are the only ones that can check, then, and do anything about it?

Mr. ROLLE. Who could do anything authoritative about it. We, of course, can urge.

Senator MALONE. Well, have you urged?

Mr. ROLLE. We have.

Senator MALONE. Do you have any communications with the Office of Defense Mobilization that you would like to put into the record urging it to go a little faster in the production of this material or urging them to authorize a greater amount?

Mr. ROLLE. Well, I don't believe that there have been any since the frozen expansion program was unfrozen, in August or September of this year.

There was, of course, during the course of that freeze period, considerable correspondence from the Department of Defense to the Office of Defense Mobilization.

Senator MALONE. Who makes up this board, in the Office of National Defense, that makes a recommendation to the Secretary of Defense?

Mr. ROLLE. Well, there is no board, sir, now that the Munitions Board is superseded.

Senator MALONE. I am not talking about them. We are clear beyond that. What personnel make this recommendation to the Office of War Mobilization?

Mr. ROLLE. You mean as to what they should do about something they have from us?

Senator MALONE. Yes. Just like titanium, that is under discussion.

Mr. ROLLE. Well, I am not certain as to what provisions in detail Dr. Flemming has for securing advice and assistance, but it is, in my understanding, an administrative decision.

Senator MALONE. Whom do you work with?

Mr. ROLLE. I work for Assistant Secretary Thomas of the Defense Department.

Senator MALONE. Are you the only one that he has working on this business?

Mr. ROLLE. No, sir.

Senator MALONE. Who are they?

Mr. ROLLE. You mean his entire staff in this field?

Senator MALONE. Whom do you work with? There would not be over three or four hundred of them, would there? Name two or three.

Mr. ROLLE. Well, sir, Mr. Thomas's deputy is Mr. Pike. He is the Deputy Assistant Secretary. His staff director in that field is Mr. Kenneth E. Turner. He is staff director for production. I am Mr. Turner's assistant.

Senator MALONE. Who is Mr. Turner? When did he come into the act?

Mr. ROLLE. He came into the Department of Defense in the early part of 1953.

Senator MALONE. Where is he from? What is his experience in this field?

Mr. ROLLE. He is a production man from one of the General Motors divisions.

Senator MALONE. And he really has charge of the titanium manufacture; that is, the amount of titanium to be recommended to the Secretary?

Mr. ROLLE. Yes, sir. His function would be, on behalf of Mr. Thomas, just as I am here on his behalf to urge.

Senator MALONE. That makes two of you.

Mr. ROLLE. If we are to go down the line beyond that, we get to the member of our staff who really knows something about titanium. That is Dr. May, to my right, who I believe you are acquainted with.

Senator MALONE. I am very happy to have someone who is connected with and understands something about titanium, Dr. May.

Do you want to turn the rest of the questioning over to Dr. May?

Mr. ROLLE. If it is to become a matter of technical questions or something of that nature, sir. As far as the policy aspects of what the Department of Defense has or has not done, I will undertake to answer that myself, if you will.

Senator MALONE. Then, Mr. Thomas, as Assistant Secretary of this Division, really studies, approves or disapproves all of the material you bring to him, regardless of who has worked on it. He is responsible then for the amount that is recommended for the three services. The total amount, then, that he would recommend to the Secretary, he passes on himself?

Mr. ROLLE. That would be correct, sir.

Actually, this latest submission took place prior to Mr. Thomas's appointment.

Senator MALONE. That is 35,000 tons.

Mr. ROLLE. Yes, sir.

Senator MALONE. But right now it would go to Mr. Thomas, and he would add up what all his assistants, such as you and Dr. May and others, say about it?

Mr. ROLLE. That is right.

Senator MALONE. And then he would make a report to the Secretary of National Defense?

Mr. ROLLE. That is right. And among other things, that he would do, as his predecessor did, in this case it being principally Air Force, he would call Mr. Lewis, the Assistant Secretary of Air Force, into consultation, who would bring in any of his people he needed.

Senator MALONE. He got the recommendations of the Air Force, the Navy, and the Army. Then he sets all of his staff to work, which includes you?

Mr. ROLLE. This is right, sir.

Senator MALONE. And when you come back to him with this recommedation, does he again submit it to the heads of the Departments?

Mr. ROLLE. It would not be submitted officially, no, sir. In pulling the thing together, we normally discuss these matters with, in this instance, principally Mr. Lewis's staff, which would include General Metzger and some of his counterparts in Washington; and in the event theer were any particular disagreement, we might recommend that Mr. Thomas and Mr. Lewis get together and settle. Otherwise, if I can go to Mr. Thomas and say, "This is the recommendation; it is in consonance with what the Air Force says they need, and they agree with our views on it," he goes ahead.

Senator MALONE. The point, however, that you make, is that Mr. Thomas is ultimately responsible for the amount that is recommended to Mr. Wilson?

Mr. ROLLE. That is correct.

Senator MALONE. Mr. Wilson goes to the Office of Defense Mobilization, and the Office of Defense Mobilization recommends to the General Services Administration, who then proceed with the contracts. And the contracts must be checked individually with the Office of Defense Mobilization?

Mr. ROLLE. As to that last point, I am willing to be corrected by ODM if I am wrong. That is my impression.

Senator MALONE. Then, other than being checked, they are let by the General Services Administration, and then they are responsible for securing the contracted-for production. Is that true?

Mr. ROLLE. That is my understanding.

Senator MALONE. I will just ask you one more question. And I think we have probably gone far enough into it.

Have you continually kept abreast of the need for this material? And what plans do you have now for making any recommendations that would conform with the known needs at this point?

RESURVEY

Mr. ROLLE. Senator, in view of the statements which have been made recently, some of which I heard, on Tuesday, by the airframe and engine manufacturers, which I must say are far greater than anything that we have ever seen them make on paper officially, we are getting together with the Air Force to have another survey made, which will result presumably in a revised figure coming to us from the combination of the Air Force and the Navy Aeronautical people.

Senator MALONE. And it will again go to the Office of Defense Mobilization?

Mr. ROLLE. Correct. And if we can substantiate a demand in excess of 35,000 tons, I can assure you we will let ODM know about it as soon as we are reasonably sure of it ourselves.

Senator MALONE. You are not reasonably sure that there is a demand for this material?

Mr. ROLLE. Sir, I take this position, and I believe Mr. Thomas will back me up. We are taking action with ODM, asking them to do things which eventually result in the expenditure or at least the obligation of a large amount of the taxpayers' money. We feel it is our responsibility to have a good look at these things before we place a demand upon ODM.

Senator MALONE. I think you are absolutely correct. Did you consult with the producers of airplanes last year before you made this recommendation?

Mr. ROLLE. We did not personally, sir. The aircraft production people did that. And I believe they sent us copies of a lot of the backup data, and they had book, chapter, and verse from these people as to where they then expected to use it. I don't mean to imply that these larger figures that the aircraft people now speak of are wild dreams or anything not correct. We are going to move in as fast as we can, however, and catch up with them, now.

Senator MALONE. What is your background in the manufacturing of airplanes?

Mr. ROLLE. In the manufacturing of airplanes, sir?

Senator MALONE. Yes.

Mr. ROLLE. None; except I have been in a few plants. But I have no background in the industry.

Senator MALONE. Let me ask you another question, then.

In view of the importance of titanium, regardless of what you recommend, would it not be at least reasonable to keep track of the progress of contracts and production, and also what progress they are making in the manufacture of planes, so that from day to day you have that information?

Mr. ROLLE. I believe we have that, sir.

Senator MALONE. You mean you had it before this hearing started.

Mr. ROLLE. Dr. May?

Dr. MAY. Yes, we have followed very closely, Senator, the progress of production of the contracts which have been let by GSA.

Senator MALONE. That is contracts. But, Dr. May, have you followed the developments in the design of airplanes to know the need for this material?

Dr. MAY. Well, Mr. Chairman, I am not experienced with aircraft manufacture. We get our information from headquarters, Air Force, as to the need for titanium.

Senator MALONE. General, would you like to tell us something about this matter at this time? Apparently we have got all the titanium that the Board says we need. They are not convinced now. It may take several months. We are not going to try to convince anybody, but I thought we brought out enough evidence to indicate the need.

General METZGER. Senator Malone, I hope to get together with Mr. Rolle, Dr. May, and their people, and arrive at a set of ground rules which will permit us to develop a requirement which is more or less in consonance with the testimony of our manufacturers.

Now, I mentioned this morning that the requirement which we presented was built around a certain set of ground rules. I personally took issue with the ground rules before. But that is another subject.

Senator MALONE. You are talking now, General, about the number of planes and the type of planes, and the materials that should be used in their manufacture?

General METZGER. No, sir, not specifically that. For example, if we are requested by the Assistant Secretary of Defense, Supply and Logistics, to present requirements for titanium, by years, for 3 years, based upon approved applications of titanium, we immediately eliminate all of the planning and all of the applications which have failed to pass a static test on an airplane, or a 150-hour test in an engine.

If, further, we generate requirements, on the basis of a dollar ceiling, of $15 a pound, we further restrict and reduce the requirements.

Senator MALONE. Did you find an objection in the national defense organization to paying $15 a pound for this material for national defense?

General METZGER. No, we found no objection. We received, as Mr. Garrett testified—I believe those were the recommendations of the research and development people to the Munitions Board, and they were passed on to us. It became evident to us that those two factors, which were incorporated in the requirement study, one the $15 a pound and the other more or less approved application, would eliminate the planning which our aircraft manufacturers have stated in this testimony, and engine builders have incorporated in their requirements.

Senator MALONE. They have gone ahead, as they always do, in spite of any recommendation from national defense, to try to make a plane that will meet specifications and keep ahead of anything in the world.

MUST PLAN AHEAD

General METZGER. That is correct. And it is evident, it is elementary, in my opinion, that you cannot live on a day-to-day requirement; that is, on an approved design basis; or on a current price structure. You can't live with that, and ever stay out of scarcity and short supply, with an accelerated demand. You will always have it.

In other words, we must plan beyond the immediate use, follow the trend, and establish a requirement based upon planning factors.

Senator MALONE. That the builders know about?

General METZGER. That they are building toward, that they know about.

Senator MALONE. One of the things we are trying to get away from, General, is rationing. We have had it for 20 years. When you start rationing material, you take all the potential investors out of it, because then the Government is in it.

General METZGER. Well, I agree with you, Senator. This rationing business results, in our terminology, in allocation. We are allocating titanium today in my Division for the Air Force and the Bureau of Aeronautics.

Senator MALONE. And still we say that we are not yet convinced, in this great organization of national defense, that we ought to study it and try to do something about it.

Now, that was my question to you.

General METZGER. It is very deceiving. It is merely a license to buy. And the fact that I certify to a manufacturer that he may buy so many pounds of titanium doesn't mean he is going to buy it. If it isn't there, he doesn't get it.

Senator MALONE. In other words, we are seeing to it, just like we have in practically every other strategic material, that we are going to be able to ration titanium. We are not looking ahead of that time at all. Is that right?

Mr. ROLLE. That certainly is not our intent, sir.

Senator MALONE. What is your intent? I would like to know what it is. You heard what the Secretary said as to what the intent was, but I do not know whether you agree or not.

Mr. ROLLE. Our intent is to send over the Office of Defense Mobilization and stand up on our hind legs and defend any requirement which Mr. Talbot is willing to certify to my boss.

Senator MALONE. How long have you been in the service?

Mr. ROLLE. As a civilian? Since 1946. And prior to that in uniform for 4½ years.

Senator MALONE. You heard my quotations from excerpts from the White report this morning?

Mr. ROLLE. Yes, sir.

Senator MALONE. And you heard what Mr. Truman did about it? He followed it.

Mr. ROLLE. I knew about that in 1946. I was not aware of the White paper.

Senator MALONE. I have here in my hand a book Raw Materials in War and in Peace, Department of Social Sciences, United States Military Academy.

Now, who makes up this Department of Social Sciences?

Mr. ROLLE. I am not sure. I mean, I don't know who the members are. They may be listed in the book or in the faculty of the Academy.

Senator MALONE. Apparently they are not listed in the book. At the same time, it is a textbook for West Point and our Naval Academy.

Mr. ROLLE. If I may say, Senator, following the last time I was a witness before your subcommittee, we have gone to the Army and told them that they had better get that out, and if they are going to discuss a subject like that for the indoctrination of military officers, they had better make it more objective.

Senator MALONE. Do you think your recommendation may result in discarding this book?

Mr. ROLLE. I don't know that it would result in discarding it.

Senator MALONE. But you have recommended that, have you?

Mr. ROLLE. We have not recommended that they stop teaching that subject. We are recommending only that they tell both sides of the picture and not draw a conclusion.

Senator MALONE. Would it interest you to know that this book reads just like the White memorandum and the Truman recommendation?

Mr. ROLLE. I know it reads like President Truman's recommendation.

Senator MALONE. Well, I cannot tell you that he based it on White's recommendation. I can only tell you that it coincides with it.

Mr. ROLLE. It certainly seems to.

Senator MALONE. For 20 years, through our Government departments, we have said that we must become dependent on foreign nations for our strategic and critical materials and save our own. Mr. White recommended saving them, for two generations. If we continue this method, by that time someone else will own them.

I would like to read a little excerpt here. I certainly do not want to take the time of the committee, though. I brought it to your attention before, because your name is in it.

Mr. ROLLE. As one of the persons consulted by the author of the book?

Senator MALONE. Yes. You were consulted by the author of the book.

Mr. ROLLE. I again disclaim any consultation on those parts or points.

Senator MALONE. It says on page 12 of this book, published in 1947—was this published originally before that? Were there subsequent issues? Or do you know anything about that?

Mr. ROLLE. My impression, sir, was that that was a new effort on the part of the faculty. I do not know that there was an earlier edition.

Senator MALONE. You know, I have some boys over there at West Point and the Naval Academy. One big red-headed boy of mine of whom I am very proud is playing football tomorrow. And if he becomes indoctrinated with this, I would be inclined to pull him out of the organization, if I have any further authority. His name is Gammell. I just hope that your recommendations may bear some fruit.

It says, among other things, on page 12, tying it back to the White letter and to the statement by the former President of the United States that it is a policy of this Nation to buy many of these materials from foreign nations and preserve our own.

> Among the minerals, the principal requisites for industrial power are coal, iron ore, and petroleum—

Then we drop down to this paragraph:

> The group of minerals of secondary importance includes potash, phosphates, and nitrates for fertilizers and chemicals, bauxite for aluminum, sulfur for chemicals, copper for electrical equipment, lead for storage batteries, for cable coverings, and for pigments, and finally, zinc for galvanizing and brass.

Then they go into the ferroalloy metals.

> Although not basic to industrial development, the ferroalloy metals—chromium, manganese, molybdenum, nickel, tungsten, and vanadium—are of vital importance due to the increased efficiency and greater utility afforded to iron and steel products by their use.

Then it says:

> The production and sale of these materials, in fact of all materials required by a modern economy, were long regarded by some governments as a legitimate field for private enterprise. A title to land, in British and American law, carried the right to exploit whatever minerals or other products the land might yield. The owner of the property was subjected only to the degree of regulation prescribed for other industries—

meaning, of course, paying his taxes and conformity to state law.

Then they say:

As the essentiality of such products to the national economy became increasingly apparent, public interest in them grew to the point where today they are regarded as national assets of such importance that uncontrolled private exploitation must be regarded as a vanishing phenomenon.

And it just nearly did vanish from America, too. Well, I hope it has not.

Contrary to general opinion, state control of raw materials is not limited to totalitarian regimes. A steadily rising number of states which purport to maintain a free economy, have progressively reduced the freedom enjoyed by private enterprise in the production and export of raw materials.

That is what I think the election was based on last fall, one of the points.

The trend is most marked in states like those of Latin America, where industrialization has lagged, and national prosperity is tied to the world price level of raw materials. In most instances, countries in that position have declared illegal the acquisition of new mineral lands by private enterprises.

In other words, production has lagged, so they declare it illegal.

France, a land of balanced economy, did likewise.

And was on our payroll for all the taxes they pay, we being still in the private industry column.

In Germany, ever since medieval times, all subsoil minerals have been state property.

Then it recommends that you read the Encyclopedia of Social Sciences (The Macmillan Co., 1937), volume v, page 515.

The net result to date of this trend is that in virtually every large state except the United States and Canada, the acquisition of new minerals sources is illegal.

Do you agree with that statement?

Mr. ROLLE. The acquisition of what? I didn't get that.

Senator MALONE. You should study this great book. You are living by it, whether you know it or not.

The recommendations on the rate of improvement in titanium production and the source of raw materials that you are using looks like you are living by it right now. All foreign production, practically, Australia and India.

In Germany, ever since medieval times, all subsoil minerals have been state property. The net result to date of this trend is that in virtually every large state except the United States and Canada, the acquisition of new minerals sources is illegal.

It has to be done by the state.

I presume 50 times in the last 7 years on the Senate floor, I have described how they escape any agreement with us made in trade through this control and the manipulation of the value of their currency.

Government ownership and control takes various forms with the U. S. S. R. providing the extreme example of complete nationalization.

That is presumably the ideal.

Although the United States has avoided general control measure, there is a growing awareness that raw materials are a national as well as a private asset.

Therefore, coming back to their recommendation that the national Government should control all of these assets, Mr. Ickes used to withdraw these lands and say, "We will save these minerals and materials and procure our supply from foreign nations"—following, I suppose, the same line of persuasion.

Sometimes I suppose it is pretty hard for some of you in Government affairs to know where you really do get your instructions.

Reading now from page 83:

> Government intervention into the problem was expressed in two directions. On the one hand, conservation measures like the Government's setting aside of mineral-rich areas represented the positive approach.

Mr. Ickes set aside large areas where the prospectors could not go—saving them for the future.

> The same can be said for the modest support given to American citizens engaged in the acquisition and exploitation of foreign sources of supply.

You see?

> The same can be said for the modest support given to American citizens engaged in the acquisition and exploitation of foreign sources of supply.

They want to encourage that production. In other words, through taxes and through the advancement of large sums of money.

You were here when it was shown that in the stockpile contracts, we are paying more for zinc and lead in Africa than we are paying in America. These foreign contracts contain better terms for foreign contractors than domestic contracts contain.

Those are only two of the metals. I will not go into the rest of them. In other words, they want to encourage American producers to go abroad—so that you cannot get the raw materials at all in wartime. That is something they do not tell you, but it would do well to study a little of it.

> High tariffs, on the other hand, stimulated the depletion of domestic reserves, as did also the operation of Federal antitrust laws. A supplemental activity was the furnishing of informational and technical assistance.

In other words, by evening the wage standard of foreign nations with our own wage standard, with a tariff, we have depleted our domestic reserves. And that is wrong, according to this book.

Now, there is no record of any mineral, and I defy you to show me one, where there are not more reserves today than there were when this book was written—by allowing domestic development. We were out of tungsten, according to a great many experts, before World War I. Yet we have more tungsten today than we ever had in the history of the world; and that applies to all these other minerals. And you had, as you heard here, more ilmenite in the United States and Canada than you could use in a hundred years; and still you are shipping it in from widely separated areas across the oceans—following the book, I suppose.

Mr. ROLLE. Of course, on that particular point, I believe the gentleman from TMCA testified it is principally a matter of the producing companies' choice as to where they get their raw material. I don't believe the Government specifies, there.

Senator MALONE. No; the Government could not possibly encourage them to develop.

Mr. ROLLE. Oh, I think we could.

Senator MALONE. Do you think it is a good idea?

Mr. ROLLE. Why, certainly. You mean to build an industry on domestic materials? Certainly it is.

Senator MALONE. I mean do you think it is a good idea to encourage them to do it?

Mr. ROLLE. We have no function in contracting those companies.

Senator MALONE. Yours is the Government operation that writes the contracts.

Mr. ROLLE. The Department of Defense doesn't.

Senator MALONE. Of course, there could not possibly be any connection between two Government departments. We understand that. But we do kind of hope when you get through you will get acquainted with some of them.

Mr. ROLLE. Sir, I appreciate all that you say. The only thing I believe we should make clear is this: That the Department of Defense does not purport to be a group of minerals economists or knowledgeable people in the field.

Senator MALONE. Do you think you are able to understand how much of the material you need, now that you have heard the evidence?

Mr. ROLLE. We are certainly able to understand what those who need it will tell us they need.

Senator MALONE. You have no training in this business yourself at all, do you, sir?

Mr. ROLLE. What business? Minerals?

Senator MALONE. Minerals, titanium.

Mr. ROLLE. Well, some.

Senator MALONE. Dr. May, are you an engineer?

Dr. MAY. I am a geologist by profession and mineralogist.

Senator MALONE. Then you know something about the business.

Let us go ahead on page 134. This is a book you teach the generals, and when they are turned out, they are supposed to be indoctrinated with all the necessary information:

Unfortunately—

it says here—

the influence of powerful pressure groups was strong enough to prevent the operation of the "Buy American" clause which vitiated the 1939 act and which now reappears in Public Act 520.

This is an argument against what Congress has done. It is very interesting.

That clause in effect prevents the addition to the Nation's overall reserves—including stocks held above ground by Government and private industry—of a single ounce of the wanted materials unless specific stockpiling purchases from domestic producers are determined to be "inconsistent with the public interest" * * *

That is what Mr. Truman determined, that they were inconsistent with the public interest, on May 23, 1946. That is when you became employed by the Government?

Mr. ROLLE. Well, I was working for the Government before then.

Senator MALONE (reading):

In effect, the "Buy American" clause places the burden of proof on the Government whenever it desires to buy abroad a single ounce of scarce material for its stockpiles so long as it is available in any quantity, however small, from domestic producers. Obviously no such state of affairs could continue if the Nation's citizenry understood the situation.

I am not so sure but what they did understand it last fall. At least, they are beginning to understand it.

Until it does understand, ignorance and complacency must continue to stand in the way of our taking out this minimum insurance of national security.

In other words, to close up our own mines and our own production of material and become dependent on offshore areas across major oceans, where you cannot possibly secure the material in time of war.

I dislike repetition, but I was special consultant to the Senate Military Affairs Committee during World War II, and they were sinking 80 percent of the ships coming out of North Africa with manganese and chrome for the first 7 months of the war. And I think you would not have to go far to know that if we had not whipped that situation, we could have lost that war. And you could lose it a lot easier this time.

You do not agree with this book, I take it?

Mr. ROLLE. I certainly don't. As a matter of fact, a lot of the statements there would indicate to me that the author perhaps never took the trouble to read the "Buy American" Act. I don't believe the act says what he quotes it as saying.

Senator MALONE. Have you ever read the White letter? That sounded like Mr. White wrote the book.

BUY AMERICAN ACT

Mr. ROLLE. But I have read the "Buy American" Act, and I know the "Buy American" Act does not preclude——

Senator MALONE. And you probably read the Tariff Act, and it never said anything like what they are saying here. What it says is that right at the moment the Tariff Act, to which the determination of the duties under the Constitution of the United States, which were placed on commerce, would revert if the 1934 Agreements Act was not extended, has now been extended to June 1954. If it is not extended, it reverts back to the Tariff Commission and the Congress, on the basis of the difference in cost. It was testified here that there was 11 cents a day labor for Indians working in the production of ilmenite ore in southern India. You know what you pay here, about $11 or $15 a day. Over in Australia you pay about $4, I think. So you probably are saving a little money there, by becoming dependent for a foreign item you could not import at all in wartime.

I recommend that you study that book further yourself, if you have any misgivings. And if I had my name on it, I would write them a letter and disclaim the whole business and send the committee a copy of it.

Mr. ROLLE. Well, sir, I might want to take you up on that suggestion.

Senator MALONE. Right now you are pretty much on record as being in accord with its provisions by having your name in the preface of the book.

We thank you very much, Mr. Rolle, and the information that has been secured, is available to you, you understand, not only on titanium but other matters—I understand that your organization is not a committee. It consists of a body of men who make recommendations to Mr. Thomas, who in turn makes recommendations to Mr. Wilson. But titanium is not the only material they cover. They cover a general range of all necessary materials.

Mr. ROLLE. Any material which is of interest and necessity to military production.

Senator MALONE. You may be interested, then, that Monday we are starting hearings on the availability of petroleum in the United States. I do not know who will be the first witness. It might be a private company. It might be the Government, the Petroleum Administration of the Department of the Interior. It is likely to be of interest to you. Right at the moment, the committee is unofficially informed that we are rationing all production in most of the principal petroleum States. Some of these light wells, when they go out of production, they tell me, do not come in again. All of that may come into the picture. But we are slowly becoming dependent on foreign areas for the same reason, just as Mr. White and Mr. Truman, and now your book on critical minerals and materials suggest. The less anyone knows about a subject, you know, the prettier the book is produced. And you are teaching these kids who do not know better.

Who controls the operations of the United States Military Academy?

Mr. ROLLE. The Military Academy is administered by the Department of the Army.

Senator MALONE. Then who are the men who write these books? Who are responsible for them? Does somebody pass on it, like with your titanium estimate?

Mr. ROLLE. I don't know, sir. As far as I know, the management of the Academy comes directly under the Secretary of the Army. It is not a matter which the Department of Defense, as a whole, that is, the Secretary of Defense, participates in.

Senator MALONE. The Secretary of the Army? Or the Secretary of National Defense?

Mr. ROLLE. The Secretary of the Army, in my understanding.

Senator MALONE. Not the Secretary of the Navy?

Mr. ROLLE. Well, he, in turn, of course, is presumably responsible for Annapolis, for the Naval Academy.

Senator MALONE. Could you do a little chore for the committee?

Mr. ROLLE. I would be glad to.

Senator MALONE. Find out how these great editorial works are provided for the two academies. The committee is very much interested in this book.

Mr. ROLLE. I will try and do that.

Senator MALONE. It is very much interested in the similarity of its teachings to those of Mr. White and Mr. Hiss and Mr. Truman. And do not misunderstand me. I do not think Mr. Truman was ever disloyal. I think he just did not understand what was happening to him. But we are supposed to understand. And I still have that book, in the year of our Lord 1953, when a different crowd are responsible for it.

Mr. ROLLE. I haven't gotten a confirmation of it, Senator, on my last inquiry, the inquiry I had one of my people make. We were given to understand that that book was not now being used. However, it is probably still in the library up there if anybody wants to pick it up and read it.

Senator MALONE. Well, when did they cease using it?

Mr. ROLLE. That I am not sure of. I haven't had it confirmed that they have ceased using it.

Senator MALONE. Well, will you ascertain whether they have ceased using it, if so, on what date, and who is responsible for writing these works, and make that information available to this committee?

Mr. ROLLE. All right.

Senator MALONE. I hope, Mr. Rolle, that you understand that the committee wants to be helpful in the production of titanium. The only time we get a little impatient, on any of these materials, is when we find that apparently there is no connection between departments that make recommendations and we can find little sense in the reduction of their recommendations, and then can find no connection with a followup after a contract is let. And especially when we find a little reluctance, as we did in one case at least, in telling us just exactly what they are doing.

Mr. ROLLE. I am sure you will find no reluctance from our office, and any time we can shed any light, we will be glad to.

Senator MALONE. I appreciate it. And I would appreciate it if you will let us know within a couple or 3 weeks what the plans are about future production of this material.

Mr. ROLLE. All right. I will do that.

Senator MALONE. The hearing then will close on titanium, subject to the call of the Chair; and on Monday at 10 o'clock we will meet here on a study of petroleum. That study will also include, of course, the manufacture of synthetic petroleum from oil shale and from coal.

(Whereupon, at 12:45 p. m. the hearing was recessed subject to the call of the Chair.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

THURSDAY, JANUARY 28, 1954

UNITED STATES SENATE,
SUBCOMMITTEE ON MINERALS, MATERIALS, AND
FUELS ECONOMICS OF THE COMMITTEE
ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to call, at 2:30 p. m., in the committee room, 224 Senate Office Building, Washington, D. C., Senator George W. Malone, chairman of the subcommittee, presiding.

Present: Senators Malone and Murray.

Present also: Jerome S. Adlerman, counsel to the subcommittee; and George B. Holderer, subcommittee engineer.

Senator MALONE. The subcommittee will be in order.

Mr. Roy T. Hurley, chairman of the board, Curtiss-Wright Corp., will be the first witness.

Mr. Hurley, will you have a seat at the table.

You have already appeared before the subcommittee. You know the objectives of the committee under Senate Resolution 143 to determine the availability of these critical materials to this Nation in time of war.

There has developed over several months of hearings and testimony from high Government officials and experts from industry that many of these materials are, in fact, very scarce and that we are dependent on raw materials from across one or both major oceans to manufacture metals we can't fight a war without. Titanium is one of the materials that has comparatively recently become a very strategic metal.

Of course, the metal has been known to engineers for many years, but the emphasis on airpower has made it—according to the testimony of men like Mr. Douglas of Douglas Aircraft, Robert Gross of Lockheed, and many others—an indispensable material. In other words, it has been testified it is a "must" in production.

For 3 or 4 years the Government officials have worked on the matter. However, comparatively little production has resulted. Testimony showed we need at least 150,000 tons annually for military and commercial aircraft. Government and industry would purchase the metal gladly at the present price which, although high, would be feasible to use because of the saving in weight in the plane and increase in the payload.

It has been testified—and I think you testified before this subcommittee that if known ahead of time—that 1 pound saved in the airframe through the use of titanium on account of its lighter weight and

being a stronger material, will probably result in a saving of 8 to 10 pounds per pound saved in the airframe. We know that you need to know the supply of titanium, you need to know when you can get it and how much in order to take the designs off the drafting board.

We have asked you to come before the committee again today because we are nearing the end of our hearings on that particular metal and we wanted to have available to the committee any additional information you may have gotten since your earlier appearance.

Would you in your own way give us the benefit of any information you think would be helpful to the committee, continuing your testimony that began some weeks ago before the committee.

STATEMENT OF ROY T. HURLEY, CHAIRMAN OF THE BOARD, CURTISS-WRIGHT CORP.

Mr. HURLEY. I repeat what I said before: that titanium is a "must," and if we are going to retain world leadership, there is no question but that we have to have it. We must have world leadership in the air because we cannot have a second best air force to win a war. You have to have titanium.

At the hearing the word "reluctance" and other words of that nature developed. They described risks. In reflecting on that, I think I stated that we had no reluctance to use the metal. It was merely a matter of getting it, and we should have it. We are already too late. We have made a proposal to the Air Force that we be allowed to modify our Buffalo plant so that we begin to melt, if necessary, from the sponge and to extrude, and by extruding make the pieces close to the finished size to minimize machining and chips and put those parts into the engines. We start doing it with 2 or 3 pieces and build up just as rapidly as we can. We begin with a program starting with a pilot line and a suggestion that in 2 years we build up to 500 tons a month; that we would use that much if it were available.

Senator MALONE. To use that much sponge or metal after it has been adapted to the shapes?

Mr. HURLEY. That would be the basic metal before it is machined. That would be for our own requirements. We felt in doing that, we would put this thing into motion, in production, and we would find that the American manufacturing man would solve the so-called problems that people think are there and that they talk about. We could talk about them for 10 years, but if we start and do it, I think the solution will be found to many of these problems.

I am a little amazed and a little surprised when I reflect on it here. I am an engine builder going out to root out the basic metal I need to do my job, and in a sense it looks as though maybe I am a little out of character in doing that. But I think that is the thing to do. I think it is important and should be done. There is no question about the economics of it, even at today's costs. The metal will pay for itself.

Senator MALONE. Review the cost, just for the record.

Mr. HURLEY. The cost that we have had referred to us runs about $15 a pound.

Senator MALONE. For the metal?

Mr. HURLEY. Yes. I am not sure we can accept that. The sponge, we have been told, is $5. I believe, however, if we get busy ourselves

and put some of it into production, we will soon find out what the real costs are and we will be able to reduce them. If we cannot reduce them, the pound of titanium is saving money for you every hour you fly the airplane and run the engine. Those savings over the life of that engine in the airplane makes it economically a good thing to do, even though we are unable to reduce costs. When we get going and into production, we will be able to reduce cost.

Senator MALONE. Do you agree with the testimony before the committee that even if the military demands slacken, that the commercial demand for planes due to the saving in the weight and resultant increase in payload, that the demand is there at the present price?

Mr. HURLEY. I think you have proof of that in the fact that Mr. Douglas, whom you referred to, put it in the DC–7 and the DC–7S, which is the latest model of a long range of airplanes that has consistently reduced the airline operating costs. That is the American approach to reduce cost. I do not think anybody will question the commercial market for it. If it is good in airplanes, it should be good for railroads and other things.

Senator MALONE. Then if the demand is there in the commercial market, then there is little chance taken or a gamble taken by the military people in demanding that the metal be manufactured and backing up that demand through Government contributions since there will be a sale for it in the civilian market if in fact the military demand decreases.

Mr. HURLEY. I cannot conceive the military making a mistake in getting titanium in production because in the history of all metals that have become available in production, they have all gone forward. Their demands have all increased, and therefore their costs have all gone down.

Senator MURRAY. In the hearings we had in Los Angeles, they referred to the history of aluminum production, how expensive that was to start off but how rapidly the price came down as a result of the progress.

USES WILL BE MULTIPLIED

Mr. HURLEY. To assume titanium is going to be different, you assume the forces of nature are going to be changed. I do not believe they are. I think it will be used and the cost will go down and the uses will be multiplied.

Senator MALONE. But the demand is what will cause the price to go down?

Mr. HURLEY. That is right.

Senator MALONE. I am just sending someone for the latest issue of the Engineering and Mining Journal, and I will read it into the record. Some commentator in the manual magazine, through the committee, said that we have uncovered a shortage of titanium but what are we going to do with it if the military demand decreased or it was outmoded or some other metal took its place? The inference is that there will be a great chance taken by the military or anyone in going into the business. They don't refer to a metal that could possibly take its place, but if we did invent one it would still be worth it.

Mr. HURLEY. You can look at that several ways and find the reasons to feel sure the metal will be used. Titanium has a high melting point.

It has a very tenacious oxide. Those two characteristics make it of value for any high temperature work. I am sure they will find uses for it. That is, fields we are not even considering today. That is the natural thing to happen.

Senator MALONE. Then with the speeds we hope to attain, around the sonic speed, do you agree that aluminum sheathing on a plane starts to lose its effectiveness and you have to go into either steel or titanium? Steel is too heavy and titanium is the only known substitute that would be effective?

Mr. HURLEY. Yes. If you look at our new inventions—most people fail to recognize this—the turbo prop or turbo jet has no cooling system. All our reciprocating engines have had either liquid cooling or air cooling. The jet engine has no cooling. You put all the air and fuel in there and burn it, so the metals around it are all subject to high temperatures. Those temperatures are of an order that the aluminum loses its physical properties and titanium does not. That is the reason titanium was used on the DC–7's. It takes the place of high nickel steels that are much heavier and also expensive.

Senator MALONE. Then in using titanium in the high temperatures, what temperature or what speed beyond seven or eight hundred miles per hour—around the sonic speeds—would the titanium lose its effectiveness?

Mr. HURLEY. I do not believe titanium would lose its effectiveness or usefulness until you get up to what we call the thermal barrier. That is quite a way ahead of us now, and none of us know very much about what is going to take place when we get there.

Senator MALONE. What would be the temperature, approximately, at that barrier?

Mr. HURLEY. I think if we went into the thermal barrier, the way a meteor comes into it, right now we do not know any metal that would stand up.

Senator MALONE. What would that speed be?

Mr. HURLEY. It gets up close to something of the order of 3,500 miles an hour.

Senator MALONE. But anything around twelve or fifteen hundred miles an hour, titanium stands up in?

Mr. HURLEY. I am quite sure the airplane can be designed so it is cool and satisfactory in those speeds. It is not until you get into the thermal barrier that I believe we are in serious trouble.

Senator MALONE. The committee would like to establish specifically what that speed would be when titanium would begin to soften, it would be very helpful.

Mr. HURLEY. I would be glad to. I am not an engineering but a manufacturing man. I will be glad to supply that.

Senator MALONE. We are interested in establishing what the demand is or could be in the manufacture of engines, because that is your particular forte. We would like to know what effort you have made to secure this material, also where are the logs jammed?

NEED CONTINUING SOURCE

Mr. HURLEY. Our effort to date has been to prove that titanium is of benefit and can be used. That we have proved by the manufacturer, at least to our satisfaction, of some 12 or 15 engine parts. We have

not put it into production because of our inability to get what we would consider a continuing source of sufficient metal to allow us to do it.

Senator MALONE. Have you made any effort through the Government agencies or elsewhere to secure the titanium you need?

Mr. HURLEY. The titanium we have gotten—and I would like to check this—comes to us by allocation from Government agencies. We have made no special effort to date to increase the amount of titanium available.

Senator MALONE. Have you made any special effort to get more for your own manufacture?

Mr. HURLEY. We have pointed out and highlighted the desire for titanium. I believe I have presented the committee with a copy of the machineability report we published recently for the Air Force, acquainting people with titanium and its properties and uses.

Senator MALONE. There is nothing of a classified nature in there?

Mr. HURLEY. No, sir. That was work done under contract for the Air Force to make available to all industry more knowledge of titanium and to encourage its use.

Senator MALONE. I think it might be helpful to accept it as an exhibit before this committee to be available to the committee members.

I would like to call your attention to the Engineering and Mining Journal of January 1954. I have been a subscriber to this for probably 25 or 30 years. It generally is fairly accurate. But on page 67 under the "E. & M. J. Outlook" page I read, "Willy-nilly, it looks as if Senator Malone's uproar about titanium will result in boosting production near the 35,000-ton yearly output the military wants. The problem is: What to do with that capacity when it becomes obsolete, as it very likely will before long?"

Would you like to comment on that paragraph?

Mr. HURLEY. Senator, I am not a mining engineer or a metal-production man, but I would say that we have got to put titanium in production to become aware of its possibilities and to know it and utilize it to its fullest degree. To accomplish that it would certainly be my recommendation that we get under way with whatever process we have so that all of us in industry can become acquainted with it, can utilize it to its fullest advantage, can recognize fully the economics of its use. If we were to wait until the new or the improved or the ideal system came along, I am afraid we would never do anything about it. We do not wait until the ultimate airplane engine is here; we go ahead with what we have today.

Senator MALONE. I was not exactly clear as to what they meant when they said "What to do with that capacity when it becomes obsolete, as it will before long," whether they meant the titanium will become obsolete or the methods of making it will become obsolete. In any case, do you see any metal now that would make titanium obsolete?

Mr. HURLEY. I know of none.

Senator MALONE. Have you heard of any engineer discuss any?

Mr. HURLEY. No, sir.

Senator MALONE. Then I will ask, Do you agree with the Government's policy—it has been the policy, and as chairman of the committee I have agreed with it and I think Senator Murray agreed with it at the hearing—that when they let these contracts, which they did, to

the Titanium Corp. operating in Henderson, Nev., and to the Dupont Corp. operating in New Jersey, there was a clause in the contract that obsolescence of machinery or equipment, through due processes, is a Government responsibility because they need it so badly.

They are trying to improve the processes. It was testified before the committee by at least two different companies that they believed they can dodge the sponge and come directly into metal. That is a chemical process. Everyone is hoping they will. Do you believe that the Government is justified in letting these contracts with that "writeoff" clause in there that money expended for equipment that might be obsolete because of a cheaper process, is justified?

Mr. HURLEY. I have strong feelings on obsolescence. We are in an industry in aviation and we are at a time in the world when tremendous developments are taking place. A percentage of all of the machine tools we buy, all of the handtools we buy, all of the methods we use, the engines we are designing, and the planes—a substantial percentage of those things become obsolete within 5 years. I am quite sure that the same would apply to any process you use for titanium.

However, because that is a fact, we do not stop building engines and we do not stop buying machine tools, and we should not stop using titanium. I am applying a broad principle that I as a manager of a business would apply. Mr. Douglas did not stop building the DC–2 because he had the DC–3 in mind, or the DC–3 was not stopped because he had the D–4 or D–5 in mind. The DC–3 is still rendering good service throughout the country, while the DC–7 is rendering a better service.

Senator MALONE. Your point is that while you can do that in commercial work. if you are going to win battles in the air, you just have to keep on top of the heap?

Mr. HURLEY. You must. You have no choice in the matter. That can frequently be the most economic approach to the thing. It may cost less in the long run.

Senator MALONE. As long as the demand is for the military, you think they are entirely justified in having that clause in the contract?

Mr. HURLEY. That is right. I believe the President himself recently said that he was in the change of our thinking on depreciation because of the progress taking place in the world today.

Senator MALONE. This Engineering and Mining Journal is generally very accurate. I think from the general information that is available they may be justified in such a paragraph, but I had to bring it to your attention because of the wide circulation of the magazine. Perhaps the author just doesn't understand the need for it.

Please go ahead.

AIRPOWER NOT UNDERSTOOD

Mr. HURLEY. In our country there are only a few people—and this is a broad statement but a very basic one—who understand what airpower is. From my point of view there are still fewer people who know how to use airpower. By the same token there are still fewer people who know how to obtain airpower and get it at a reasonable price. Lacking that understanding, they are apt to apply yardsticks and rules and opinions and method of measurement that are in error.

I think we have somehow got to make the people recognize that airpower is the most essential thing we have in our way of life. We have got to make them understand it is moving very rapidly. If we move with it and do not throw it out of gear by applying obsolete thinking and methods, we can have airpower at a reasonable price. It we constantly throw it out of gear, constantly bringing old methods into the picture, it will become expensive. I hope I have made myself clear.

Senator MALONE. I think you have. I think you made yourself clear when you were before the committee the first time. But did I understand you to say that if our potential enemy has a metal like titanium and uses it in the construction of planes and we do not have it, then we do have a second best air force?

Mr. HURLEY. That is right.

Senator MALONE. It has been established in evidence before the committee—and I do not recall what department was before the committee at the time—that through the State Department samples of titanium had been furnished a considerable time ago to Austria. The chairman made the remark it might just as well have been mailed to Uncle Joe. So it is very likely our potential enemy knows how to make this metal by now. Would you say that is correct?

SOVIET AWARE

Mr. HURLEY. I think any prudent man would assume that the Soviet Government is aware of titanium, its benefits and uses, and are certainly working it. To consider otherwise would be unwise and foolish from the standpoint of our national security and protection of our country. I do not see how we can overlook something of that kind. We certainly know from the daily press that they are in every country of the world searching for every bit of information they can find. I am told the Japanese have a surplus of titanium sponge for sale. If they have, I wonder why we do not have more of it. If they have it for sale, certainly it is going into other areas of the world that we know nothing about.

Senator MALONE. Would you tell us, for the benefit of the committee, what effort you have made specifically to secure more of the metal? To what agencies have you applied and what the results were?

Mr. HURLEY. To date our effort has been limited to demonstrating to our satisfaction that the metal does do its job. I have been head of the Curtiss-Wright Co. for only 4 years. In that period of 4 years we have been busy developing jet engines and other engines. During that period we have determined the need for titanium and its usefulness. We have recently established for ourselves and to our complete satisfaction the need for it. We engaged in the work that is represented by that book on titanium. We have recently proposed to the Air Force that we be allowed to proceed with the melting and extruding of it so we could get the pieces into our engines in the shortest time.

Senator MALONE. What has been the result of that application?

Mr. HURLEY. The application was received with interest by the Air Force and they are studying it now. We soon hope to hear from them as to their willingness to go along with us on that proposal.

Senator MALONE. Would you keep the committee advised as to your progress?

Mr. HURLEY. Yes, sir, I would be very glad to.

Senator MALONE. It is interesting to note in a bibliography recently secured on titanium that citizens of Russia have written about 250 articles on titanium that have been published, and that the Japanese have written about 75 articles on the same subject. These are not just ordinary amateurish articles; they are written by experts and are so recognized. Of course, it is well known, as you have just testified, that Japan is in fact manufacturing a good quality of titanium. So the presumption would naturally be as you assume; that Russia, having written 3 or 4 times as many technical articles on titanium, is probably making titanium.

Mr. HURLEY. I think that is an assumption any prudent man would make, sir.

Senator MALONE. Do you have any further information as to the application of titanium to the actual engine manufacture in which you are engaged, or what titanium would do in the way of speedier or longer range airplanes and what the weight saving and speed and range might be through its use?

BEHIND SCHEDULE

Mr. HURLEY. I cannot add anything to the figures that are already in the record, but just to restate that the benefits are real and substantial. If we are to maintain air supremacy, I think we must have it. In fact, I think we are already late in not having it available right now.

Senator MALONE. Are you telling the committee that you believe that in your opinion the Government agencies that are charged with the acquisition or the securing of this material should press for additional contracts with responsible companies or agencies that have a workable method of making it?

Mr. HURLEY. I would certainly recommend that the companies that have the potential capacity and the know-how to do the job be given the job to do and to get on with the production of the material and make it available to industry.

Senator MALONE. You have reviewed the testimony that 150,000 tons annually are necessary for the manufacture of military craft that are now on the drafting board but are not taken off because the material is not available. You also are familiar with the testimony that the Pentagon recommended approximately 35,000 tons annually and that the Office of Defense Mobilization first trimmed that demand to approximately 22,000 tons annually. It has now been raised to about 25,000 tons, but the GSA has let contracts for between 13 and 14 tons annually. The evidence shows they are actually producing about 2,000 tons. You are familiar with the evidence on that?

Mr. HURLEY. Yes, sir.

Senator MALONE. Do you agree with the evidence, that we do need 150,000 tons annually if the builders and designers, including the engine builders like your company and the Douglas and Lockheed Cos. and the remainder of the structural building companies, are to take the plans off the board and start immediately?

Mr. HURLEY. I have not checked the accuracy of that figure, but just taking the overall weight of the airplanes and engines, I would say the figure is not excessive. I would carry my judgment one step

further and say that a metal with the characteristics of titanium—certainly that is not a lot of titanium for a country like the United States. I would not be surprised if careful study would increase those figures. I have no way to question them.

Senator MALONE. Testimony also showed there in Los Angeles—and Senator Murray heard this testimony along with the chairman—that in case of war and if the demand for the manufacture of airplanes increased in anywise like it did in World War II, you might need 3 or 4 times that amount for the number of planes.

Senator MURRAY. If they once develop the proper methods of producing or manufacturing this titanium, there are supplies of it that will be available and there will be no great difficulty in securing the amount that will be necessary to carry out the program. I understand Japan has tremendous deposits of it in the way of some deposits of sands that are in great volume. I do not know what other countries have it, but I suppose it will be found eventually in many part of the world.

Mr. HURLEY. I have a feeling that the requirements for it will grow because we know that for any national emergency we are in short supply on nickel. It is just a matter of not having the deposits. At the moment the material that will take the place of nickel for the stainless properties is the titanium materials. There are many basic reasons why we should go ahead with the production of it.

Senator MURRAY. I cannot see how it would be possible for titanium to ever get to the point of being unnecessary as a metal in this country. There will be a demand for it like copper. I remember there was a time when it was thought we might have too much copper. When Marcus Daly ran into copper, he threw up his hands and thought they were ruined. The manufacture of copper became the great industry of that section of the country. I am convinced that titanium will grow in demand. The use of it will be applied in many directions.

Mr. HURLEY. As we use it and begin to better understand its possibilities and properties, it is just natural that its use will broaden and go into new fields.

Senator MURRAY. The same as aluminum. Now they are using it for building barns.

Mr. HURLEY. After World War II they thought we had too big a capacity, but when the Korean war came along we knew we did not have.

The testimony of engineers of the Kennecott Copper Co. and representatives from the Bureau of Mines shows that ilmenite is about the fourth or fifth most plentiful mineral on the earth's surface. It is only a question of concentration. At the moment I do not remember the exact amount that they are producing at the Kennecott plant in Canada, which is relatively near the United States, but they are producing, I believe, a 80 percent titanium slag. All they need is the demand, they have several hundred million ton for this material.

So there is ample testimony that there is anough of ilmenite of high enough grade to meet requirements in the United States and Canada for the next 100 years. It is a important question then, since the committee is charged with determining the availability of these items in time of war, as to why we are not getting into the domestic material a little faster. Is it your opinion that that could be done by just letting

the number of contracts that would add up to the amount you need? Are you familiar with the testimony of the Kennecott Copper Co., which is only one of the companies that would like to get into business, that they did not have a sale for all they were producing?

Mr. HURLEY. Senator, I do not think there is any question about getting the material into use if we get under way with it. I am very confident we must develop our resources within our own borders, or at least on the North American Continent.

Senator MALONE. And it can be done.

NO DEPENDENCY ABROAD

Mr. HURLEY. It can and it must be done. I do not see how we can depend on sources across the sea for anything in the event of a national emergency.

Senator MALONE. Our testimony—and I am sorry, Senator, that you happened to be away from town when Generals Wedemeyer and Fellers testified, and I do not remember whether you were present when General Johnson of the National Defense Organization testified, but they all testified that our Western Hemisphere would be the dependable supply of raw materials in time of an all-out war and that the delivery of anything across a major ocean would be problematical.

The testimony is conclusive, I am sure that there is all of the ilmenite here that we could ever need, it merely awaits development. Also, the testimony substantiates what you say, that it is a substitute for many materials that are scarce. Of course, testimony shows the nickel supply and other supplies in this country and in Canada are ample, if developed.

But you agree, from what you know about it, that this is a "must" material; that the 150,000 tons is probably a conservative estimate of annual need. and that we can develop the materials in this country and must do it?

Mr. HURLEY. I feel that we must do it. The characteristics and properties of the metal are such that it is a very desirable thing for us to do it and to get it into use as quickly as we can.

Senator MALONE. What might be your annual demand? I know this is a difficult question that would be very hard for anyone to answer, because the demand is on the demand for the engines; but what can you see in front of you, not only your own demand but the total demand in airplane engines annually, what might it develop into if it were available? Just like aluminum, all you had to do was take the planes and start.

Mr. HURLEY. An all-out use, I am not prepared to give a figure covering the weight of that. In our proposal to the Air Force we suggested that we start a pilot plant and that that be increased to 500 tons a month for our own use in a period of about 2¼ to 2½ years, feeling if we started from now it would take us about that long to develop the pieces, get them into the engines, get the engines tested and through their flight tests. From then on the use and growth of the metal should be very rapid because by then we would have established a rather thorough working knowledge of the metal, its alloys, and various methods of fabricating it.

Senator MALONE. At the end of 2½ years you would be using 6,000 tons annually?

Mr. HURLEY. Yes, sir.

Senator MALONE. That is your company alone?

Mr. HURLEY. That is right.

Senator MALONE. How many companies are in the business, and on the basis of your own percentage of production of the demand, what would you say then would be the demand for all engines?

Mr. HURLEY. Of course, there are major engine companies in this country besides ourselves. There is Westinghouse, General Electric, Allison, and United Aircraft.

Senator MALONE. Where would that run in tonnage?

Mr. HURLEY. If they used the same amount we did, that would run up to some 30,000 tons if my arithmetic is right.

Senator MALONE. Just for engines alone?

Mr. HURLEY. That is right. I would like to check that figure to be sure I am not giving you something that is misleading.

Senator MALONE. Would you do that and furnish it? And also, if you could project a figure beyond the 2½ years, it would be helpful. But we would like to add up authoritatively at the end of the hearings to substantiate whatever conservative demand there might be.

That does not include any frames or any other parts of the airplane; is that right?

Mr. HURLEY. That is right. I would be glad to do that.

Talking here suggests something to me. I think all of us in the room remember when chrome plating first came out. It was a very attractive thing and very expensive. There were a lot of doubts and questions. Today we have got chrome plating on all of the automobiles, all the cheapest products we have, because we must. We no longer polish brass or nickel. I think we are faced with a similar situation here. When we use it and know it, the demand will take care of the situation.

Senator MALONE. Take this one characteristic. It does not corrode even under seawater; is that true?

Mr. HURLEY. That is right. I have experimented on my small sailboat. I had it on the boat for a while and there was no corrosion.

Senator MALONE. It would only be a question of price so far as civilian use is concerned because there would be no need for painting or cleaning or chiseling bottoms of seacraft and the many things where corrosion is an item, is that right?

Mr. HURLEY. That is true.

Senator MALONE. Do you have any other information you think would be helpful to the committee?

Mr. HURLEY. I think that is all I can offer today. I will check these figures for you and also check the speeds at which temperature effects might enter into the use of titanium in order to be sure I have given you accurate figures.

ACID RESISTING

Senator MALONE. My attention has been called to the fact, and I think it is already in the evidence, that it is also acid-resisting. In other words, no known acid attacks it.

Mr. HURLEY. I am not familiar with its properties in that regard, but I would guess from its resistance to corrosion in salt water and electrochemical actions, it would also be good on acids.

Senator MALONE. It has been called to our attention that milk machines and tanks that are subject to corrosion, that they have a large demand for it even at the present price.

Mr. HURLEY. That is right. High temperature tubing and piping do, also. I know nothing about its use in high-temperature apparatus, but it seems to me there must be all sorts of uses for it.

Senator MALONE. Just as in your engines and for the same reasons?

Mr. HURLEY. That is right.

Senator MALONE. Mr. Hurley, any further information you can give will be appreciated by the committee. Also keep the committee apprised of the results of your application on production of titanium and application to go into the business of fabricating and extruding this metal. Within a reasonable time we will be adding up the results of the testimony. Will you keep us advised?

Mr. HURLEY. I will be glad to.

Senator MALONE. Describe what would be saved in the matter of extrusion. We have had testimony on extrusion methods by the Harvey Machine Co. They had samples with them. Do you consider the extrusion methods a practical method of handling this material and shaping it?

Mr. HURLEY. There is no question about it. I am sure it is a practical method. It has the additional advantage of producing a piece that is very close to its finished size in these unusual shapes, and it eliminates the need for machining and grinding and cutting. It produces a material of superior physical properties. So it is a good method of fabricating. It is an economical one and saves a great deal of time.

Senator MALONE. It saves the time of trimming and shaping the material after it has been cast?

Mr. HURLEY. That is right.

Senator MALONE. Does it eliminate a large amount of the scrap?

Mr. HURLEY. Yes, in the form of chips. At the moment we have a problem of how to reclaim that. That is one of the things that we will go to work on, how to utilize more of that scrap. When you go to an extrusion, you eliminate most of the scrap.

Senator MALONE. What percentage would you eliminate over the trimming and shaping after it has been cast in another manner?

Mr. HURLEY. I would say that extrusion over normal forging and casting methods, you certainly reduce the chips to one-half or one-third what they would normally be by other methods.

Senator MALONE. We understand from testimony before the committee that there is no practical method of utilizing the scrap like you do scrap steel. You just throw it back into the furnace. What, to your knowledge, do you think is the possibility of utilizing or working out ways and means of reducing the scrap so that a corresponding reduction of costs would result.

RESEARCH ON SCRAP

Mr. HURLEY. We have in mind doing some research work on a method of removing oxides and impurities that we feel shows great

promise to increasing the amount of scrap that can be used. We propose, in connection with that work of extruding or melting, to put this refining or remelting process to work, to develop it as a practical means of reclaiming scrap. How successful we will be, I cannot say; but we think it is promising enough to go ahead.

Senator MALONE. For the benefit of the committee, what percentage, if you know, is wasted in scrap under present methods?

Mr. HURLEY. I am told that at the moment they are putting about 2 percent of the scrap back into the new material.

Senator MALONE. How much of it is scrap?

Mr. HURLEY. It is not being thrown away but is being held for reclaiming.

Senator MALONE. But what amount is rejected as scrap under the methods now used in shaping? Is it 50 percent or 40 percent?

Mr. HURLEY. If you are using an extruded form for an airframe, I would say the percentage might go down to 10 or 15 percent. If you are using a forging that has to be carefully machined, it might go up to 50 or 60 percent. It will vary in the various processing.

Senator MALONE. I think the testimony will bear that out, about 50 percent on an average.

Mr. HURLEY. Substitution of extrusion for forging is the way to reduce that figure.

Senator MALONE. You understand we do not have a technical committee, and to understand what this amounts to—let us assume there is 50 percent wasted in scrap; that it costs $15 a pound for the metal, about $20 a pound for the shapes, together with the wasted scrap (although it is being saved for some future time) what would that make the shapes? At $20 a pound, would that double the amount of sponge metal that is necessary for a pound of finished material?

Mr. HURLEY. If you assume that the scrap is averaging about 50 percent, yes, that would roughly indicate about 2 for 1.

Senator MALONE. I was not clear as to just where we doubled up. You would need twice the amount of metal to make the shapes on account of the waste, but was that included in the $15 per pound, the waste and scrap?

Mr. HURLEY. If we take the extruded form where you said $20 a pound, and there you have little scrap, the net cost of the piece would not be much in excess of the $20. If, on the other hand, you took a forging at let us say $15 a pound and you had to do a lot of machining on it, then the finished cost of the piece would be a lot higher than $15. I would question that approach to looking at cost because you do the same thing with steel or brass or bronze. You do not attempt to determine the cost based on the weight of the final piece. The weight of the final piece depends more on the stress and the service, the purpose for which the piece is made.

Senator MALONE. That is true, but what I was trying to clarify for the record was the $20. Did that include the waste? If you you said $20 a pound for shapes, that includes the waste. If you saved any scrap, under the regular methods like steel scrap, it would cheapen the final per-pound cost of the shapes, is that true?

Mr. HURLEY. That is right.

Senator MALONE. It is all included in the $20 per pound?

Mr. HURLEY. I believe it is.

Senator MALONE. If you will do that, I would appreciate it because I do not think the record has been quite clear on it.

Do you have any questions, Senator?

Senator MURRAY. No. I am pleased that I was here to hear the testimony of Mr. Hurley, and I will be interested in his subsequent contributions. I think it was very interesting testimony, and I wish to express my congratulations to you for the fine statement you have made.

Senator MALONE. I think we could speak for the committee that we will offer any assistance that we can to help anyone who is exercising their energy to increase the production.

Senator MURRAY. I am sorry I have to leave now. I am attending another hearing involving metals, and I have got to get over there. It is with reference to premium prices, support for lead and zinc.

Senator MALONE. We intend to discuss that some in our own committee.

Senator MURRAY. This is just a hearing in my office because some people have come in with a proposal of something that is a substitute for the premium-price plan which does not seem to be very popular.

Senator MALONE. I think it will be very helpful if you brought that testimony later to this committee.

Unless you have some further testimony at this time, we will ask you to furnish us a supplemental statement including the answers to questions asked by the chairman and Senator Murray and any other material that you think would be helpful to us.

Mr. HURLEY. I will be very glad to do so.

Senator MALONE. At this time, that is all you have to offer?

Mr. HURLEY. Yes, sir. I will check the accuracies of these figures I gave you offhand.

Senator MALONE. Especially keep us advised as to your progress with the Air Corps or the committee whose responsibility it is to let these contracts.

Mr. HURLEY. I will be glad to do that. I have a feeling the Air Force is very much interested in using titanium. They supported this work on machineability, and it is a good indication of their desire to get it into use.

Senator MALONE. The impression of the chairman, speaking only for one member, is that they are all very much interested in it and have been a little reluctant in the past, especially some of the alphabetical organizations charged with letting contracts, because it is an expensive material.

It seems that any one connected with the Government is a little reluctant to take a chance. We hope that the work of the committee will result in the presentation of data which will enable the members of the subcommittee and the 13 members of the main committee to establish a policy on this vital question and to give full support to the Air Corps or any arm of the Government administering a firm policy.

Speaking for the chairman and for the members of the subcommittee, we hope we can fit into that picture and furnish them the support they need to do what the Congress determines ought to be done.

Thank you very much.

(Whereupon ,at 3:30 p. m., the committee recessed, to reconvene at 10 a. m., February 1, 1954.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

MONDAY, FEBRUARY 1, 1954

UNITED STATES SENATE,
SUBCOMMITTEE ON MINERALS, MATERIALS, AND FUELS ECONOMICS OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to call, at 10 a. m., in room 457, Senate Office Building, Senator George W. Malone, chairman of the subcommittee, presiding.

Present: Senator Malone.

Present also: Jerome S. Adlerman, counsel to the subcommittee; George Holderer, committee engineer, and Richard G. Sinclair, committee accountant.

Senator MALONE. The committee will be in order.

Dr. Arthur S. Flemming, Director of Defense Mobilization will be the first witness.

Dr. Flemming, will you come forward? And Mr. Charles S. Thomas, Assistant Secretary of Defense, and Mr. Edmund F. Mansure, Administrator, General Services Administration.

The committee over the past several months has conducted an intensive study and has held numerous hearings on the subject of titanium.

Representatives of the leading air-frame manufacturers on the west coast such as Lockheed, Boeing, Convair, Douglas, and so forth, appeared at the hearings in Los Angeles. In Washington we have heard representatives of both air-frame manufacturers and engine companies such as Curtiss-Wright, General Electric, Fairchild, Republic, General Motors, Westinghouse and others.

All were unanimous in testifying that large quantities of titanium metal could be used immediately if it were available, even at the present price of $5 a pound for titanium sponge. It was apparently the consensus of opinion that the present immediate requirement for titanium, if it were available, would be a minimum of 150,000 tons per year and up to 500,000 tons a year if we went into a wartime mobilization plan for the production of planes.

Titanium, it has been testified, is a "must" for superior airpower for the future. Testimony brought out that its unique characteristics of lightness of weight, high strength, heat-resistant and noncorrosive qualities are essential in the use of high speed near sonic and sonic planes.

The experts and builders of these planes testified that when this lightweight metal is designed into a plane it will result in a savings

of over 8 pounds in the airframe for each pound of weight saved by using titanium in place of stainless steel.

I need not tell you that this weight savings will give our planes tremendous advantages in extra load capacity, greater range, greater speed and maneuverability.

There have been disquieting indications that the Communists have been working on the production of titanium. A check on the bibliography on titanium shows that Russia since 1934 has exhibited a very great interest in titanium as is evidenced by some 257 articles written by Russian metallurgists and scientists. It is also a well-known fact that some of the best known German scientific brains have been working with the Russians either as willing or captive scientists.

A titanium shortage would pose a major threat to the United States airpower position. The United States cannot afford to be a second-best airpower.

We have heard almost 80 witnesses, the best experts and the best informed people from Government and industry, on this subject. We have heard testimony both in Henderson, Nev. and in Washington, D. C., from all of those who are presently producing titanium, as well as many companies who have engaged in research and who are working on various processes for the manufacture of titanium.

There has been a rapid change and an increased demand for workable titanium metal in the last 2 or 3 years, however, production has lagged very seriously.

DISTURBED AT DELAY

The committee has been distrubed that there has been undue delay in titanium production, due no doubt in large part, to the difficulties of solving the metallurgical problems. But there is no doubt that a large part of the delay is due to the inertia within the Government for failure to raise its sights on production goals.

In 1952 it is our understanding that the Defense Department had set a production goal of 35,000 tons per year. This was cut first to 20,000, revised to 25,000 by the Munitions Board, now the Office of Defense Mobilization, and the General Services Administration, the organization charged with letting contracts, had up until the time of the opening of these hearings let contracts for the production of only 13,000 tons per year and up to the time that we first held hearings the metal was being produced only at a rate of about 2,000 tons per year.

This situation has been called to the attention of you gentlemen during the course of our hearings and I know that you have given it considerable study and have taken a great deal of interest in the subject. It is my understanding that aggressive steps are being taken to increase production.

I have called you, Mr. Thomas, because you must set the requirements for the Defense Department. I have called you, Dr. Flemming, because you must pass upon and coordinate these production goals and I have called on you, Mr. Mansure, because your department must take these goals and translate them into contracts and obtain production.

We hope to close the titanium hearings today with your testimony as to what steps are being taken to obtain titanium production in

this Nation so that we can look forward to an Air Force second to none that will give us every advantage in the defense of our Nation.

So, Dr. Flemming as Chairman of the Office of Defense Mobilization, you, under certain conditions and in certain fields, are superior to the Director of National Defense in your final recommendations.

I am going to ask you to start and to give us any information you have.

It has been about 3 months since you appeared before the committee. You were entirely new in your job at that time.

We have asked you to come back today to ask you what your conclusions are and also how we can be helpful to you.

STATEMENTS OF CHARLES S. THOMAS, ASSISTANT SECRETARY OF DEFENSE; DR. ARTHUR FLEMMING, DIRECTOR, OFFICE OF DEFENSE MOBILIZATION; EDMUND F. MANSURE, ADMINISTRATOR, GENERAL SERVICES ADMINISTRATION; AND MAJ. GEN. KERN D. METZGER, CHIEF, PRODUCTION RESOURCES DIVISION, AIR MATERIEL COMMAND

Dr. FLEMMING. Mr. Chairman, thank you very much.

First of all, I appreciate the opportunity of listening to the summary of the evidence that has been presented to this committee, that you have just given us. And, as you know, I have followed the testimony that has been presented to the committee with a great deal of interest, because of the bearing that it does have on some very important responsibilities that we have in the Office of Defense Mobilization.

And as a result of considering that evidence, along with other information that is available to us in the executive branch, I decided a number of weeks ago that I should appoint a special committee in the Office of Defense Mobilization to sift all of the available evidence on the titanium problem, to recommend a proposed program for the Government to follow, and to also recommend a timetable to be followed in carrying out the program.

And then, once a decision has been made on the basis of the recommendations of that committee, on a program and on a timetable, the Office of Defense Mobilization, acting for the President, will see to it that all concerned adhere to the program and the timetable.

I have been consulting with various persons as to the kind of people that might appropriately serve on such a committee. One person that I have consulted with on this matter is the Assistant Secretary of the Interior, Mr. Wormser, for whom we have a great deal of respect in the Office of Defense Mobilization. The fact of the matter is that we feel that it is the proper and appropirate thing for us to lean very heavily on Mr. Wormser and his associates in dealing with problems of this kind.

At his suggestion, I considered the possibility of appointing as chairman of this committee, Mr. Herbert H. Kellogg, of the Columbia University School of Engineering. And after considering the matter very carefully and consulting with Mr. Kellogg, I have decided to appoint him as chairman of the committee to which I referred.

I have also asked Mr. Wormser, the Assistant Secretary of the Interior, if he will serve as a member of the committee. He has indicated his willingness to do so.

We will add one other person to the committee.

I have also consulted, through Assistant Secretary Thomas, with the Department of Defense to see whether or not they would be willing to make available, as consultants, General Metzger, who is here with us this morning, and Colonel Messick of, the Department of the Army. They have indicated a willingness to explore that possibility and see if that can be done.

TO MOVE AHEAD

It is my understanding that Mr. Kellogg will be available to get going on this particular assignment during the course of this week, and he will be able to give full time to it for the time being. We are going to stay right back of it and move just as rapidly as we can to pull all of the loose ends together and develop an overall Governmentwide program with a timetable attached to it and move forward.

In the meantime, we not only want but we urge Mr. Mansure and his associates to continue to pursue all of the possibilities that are presented to them in connection with possible development contracts.

As you have indicated just recently, an additional arrangement has been worked out with Du Pont, and my understanding is that there are other matters under consideration, and I am sure that Mr. Mansure understands that he is perfectly free to continue those negotiations, and the minute he has got a proposal to come to the Office of Defense Mobilization we will act on it. We will not sit around and wait for a report from this special committee. We will keep moving at the same time that this committee is developing an overall and what I hope will be a long-term program. And I know that Mr. Kellogg and his associates will want to take full advantage of all of the information that has been presented to this committee both in open hearings and also in executive session.

Personally, I feel that the committee has rendered a very constructive service in pointing up the nature of this opportunity in the way in which you have this morning.

Senator MALONE. Dr. Flemming, we appreciate your efforts, and I know the other members of the subcommittee and the 13 members of the Interior and Insular Affairs Committee will appreciate them. That, to me, just about closes the hearing as far as you are concerned, because it seems to me you will be doing all that can possibly be done if you move in that manner.

We have reviewed your Government contracts. We agree with the provision that is included. I suppose it is included in the first three contracts.

One I neglected to mention is Cramet, of the Crane Co. of Chicago, but it does have an obsolescence clause. I, for one, agree with this principle for the very reason that we hope that some of these companies will come up with a simplified process. Some say they think they can proceed directly through the sponge operation. Whether they do or not, there will be improvements in the process beyond any doubt that will materially cheapen the manufacturing process.

If any equipment is made obsolete by new discoveries, we think it is highly proper for the Government to take part in that loss. Otherwise, there would be no incentive for these companies to spend the millions of dollars necessary to go into this work.

Now, I am highly gratified, though I am not surprised, Dr. Flemming. I really expected the result you have just announced.

We felt from the beginning that it was not a matter of undue delay as far as the top Government officials were concerned, but a matter of lack of time.

Now, Mr. Mansure, it seems to me the load is going to be transferred to you, if the committee that has just been mentioned starts to function immediately, and I know it will.

I neglected to mention that I had asked General Metzger to be here to act as adviser to the committee because of his familiarity with the subject. General Metzger is in charge of the operations at Wright Field concerning the manufacture of planes and the amount of titanium used in the manufacture of planes.

Now, Mr. Mansure, I have received your very interesting letter regarding your progress and respect your confidence. However, if you have any remarks for the record now, they would be very helpful.

SUPPORT FROM ODM

Mr. MANSURE. Just very briefly, Mr. Chairman, first of all, we have had excellent support from the Office of Defense Mobilization. As a matter of fact, they have given us considerable leeway in carrying on the procurement of this material.

Now, our principal problem, as you have already stated, is that we are almost at the threshold of the new development in the production by several of the companies who are working very hard in the production of this material.

I say that because there have been delays in the actual production, due to their research problems, and furthermore the development of new methods.

The report of the 25th of January brings you right up to date on the progress of the individual companies.

I would also like to say that we have had excellent cooperation from General Metzger, and he has met with us, advised us on several things which we needed help on, and gave us some very valuable information in the progress to date, which was of particular assistance to me, because it gave me a better background than I had before on it.

The only reason that I am not itemizing the progress of the various companies is that I believe you already have that as a matter of the record on the report which I gave to you.

Assistant Secretary of Defense Thomas has been advised of that as well as Dr. Flemming.

If there are any questions which you have on that, I would be very glad to answer them.

The newest development, of course, is what you have already referred to, of the du Pont people.

Senator MALONE. I received a letter from you dated January 27, enclosing a copy of a report from your staff, and that is the list.

Mr. MANSURE. Right up to date.

Senator MALONE. I will ask that this list, which includes mention of negotiations with the Electro Metallurgical Co., the Dow Chemical Co., Western Pyromet Co., Horizons, Inc., Monsanto Chemical Co., and National Research Corp., be included in the record.

This also includes reference to the status of contracts executed, for du Pont, Titanium Metals Corporation of America, the Cramet, Inc., and the Bureau of Mines.

I will just include that in the record.

(The documents referred to are as follows:)

GENERAL SERVICES ADMINISTRATION,
Washington 25, D. C., January 27, 1954.

Hon. GEORGE W. MALONE,
United States Senate, Washington 25, D. C.

DEAR SENATOR MALONE: I enclose a copy of a report from my staff of status of operations under titanium program as of January 25, 1954.

As further progress is made, I will keep you currently informed.

Sincerely yours,

EDMUND F. MANSURE, *Administrator.*

STATUS OF OPERATIONS UNDER TITANIUM PROGRAM AS OF JANUARY 25, 1954

The following negotiations are under way:

1. Letter of intent transmitted to E. I. du Pont de Nemours on January 22, 1954, in order to permit it to proceed with design and engineering work for additional expansion of 7,000 to 8,000 tons per annum.

2. *Electro Metallurgical Co.*—Negotiations have covered major points of contract and are in substantial agreement. Appointment for February 2, 1954, with company representatives to prepare draft of definitive contract.

3. *Dow Chemical Co.*—Preliminary discussions resulted in advice that company is willing to construct plant having committed output of 1½ tons per day although production of 5 tons could be expected. Data being prepared by company for basis of negotiations.

4. *Western Pyromet Co.*—Arrangements are being made for this company to use one unit of Manteca magnesium plant to determine feasibility of conversion to titanium production.

5. *Horizons, Inc.*—Negotiations being commenced within next few days looking toward Government support of pilot-plant operations on new process.

6. *Monsanto Chemical Co. and National Research Corp.*—Design problems have delayed negotiations for pilot-plant contract.

Following is status of contracts executed:

1. *Du Pont.*—Construction of Government-sponsored additional capacity virtually complete. Full operation during second quarter 1954 possible provided market demand for production exists.

2. *Titanium Metals Corporation of America.*—Representatives of Boulder City station, Bureau of Mines, commenced survey requested by GSA on January 12, 1954. Satisfactory progress reported in the accumulation and review of data as of January 22, 1954. Definite advice can be expected to commence about February 15.

3. *Cramet, Inc.*—Construction progress report on schedule.

4. *Bureau of Mines.*—Pilot plant at Boulder City, Nev., continues to operate at rate of approximately 20 tons per month.

Mr. MANSURE. There is the one exception of the change with du Pont, of which you have advised the President.

Senator MALONE. That, then, does bring it up to date.

Mr. MANSURE. That brings it right up to date, with the change in the du Pont position.

Senator MALONE. And in the meantime, you will proceed with the negotiations already under way?

Mr. MANSURE. Yes, sir.

And we have had very definite instructions from ODM and know exactly what their wishes are.

Senator MALONE. Mr. Thomas, you are one of the chief deputies to Secretary Wilson. I had a short discussion with Secretary Wilson about 3 months ago.

Personally, I was impressed with Mr. Wilson. Of course, nearly everybody probably is, with his record with his own company. But whether he planned it that way or not, his operations for the first year as Secretary of Defense, to me, have made a lot of sense. He has held back construction, at least the press reports so indicate, where he thought it was either unnecessary or might prove obsolete. And the information this committee has received is that any fighting plane without titanium would come out second best against an enemy plane made of titanium. That does not mean that the manufacture of planes should be stopped, of course, because there is always a use for the kind of planes we are making now. But he has slowed up production of certain items which might prove to be obsolete. He has started to cut down on his foot soldiers around the world. The chairman has referred to them as tourist armies, and probably with our present setup, they would be destroyed or on their way to the salt mines within a very short time. We have received evidence before our committee that we cannot even feed the Army and cannot furnish them necessary equipment. But there are ways to do it, and I hope that our National Defense Director is on the right track.

Mr. Thomas, you have heard the testimony. I know you are familiar with the work the committee is doing, operating under Senate Resolution 143.

Would you have anything to add to the record?

Mr. THOMAS. Mr. Chairman, I think our particular function in this matter, that of the Defense Department, is to develop the requirements of the services. And as I think you know, some years ago that was done, as to titanium requirements, and they came up with a total requirement of 28,000 tons, and the Defense Department at that time, I think, recommended 35,000 tons, and it was eventually reduced to 22,000. That was before my time and before Dr. Flemming's, and Mr. Mansure's time. Now, those are not realistic requirements, in view of what has transpired and in view of the new types of airplanes that are on the design boards today. So we have requested that an additional study be made, and that the services give us additional requirements now based on a 5-year program, which carries through 1958. That will be available within about 60 days or thereabouts.

As soon as we get that, that will be a much more realistic requirement program, and we will then transmit that to Dr. Flemming, and we will work with Dr. Flemming and Mr. Mansure to accomplish that program.

Senator MALONE. Mr. Thomas, as the chairman has stated, this committee does not intend to look back very far except to determine what to do in the future. There was some very disturbing evidence presented to this committee. The chairman does not altogether agree with you that this information was not available to the prior organization. It was certainly not the responsibility of the present officials.

We have evidence and letters, including a letter from Mr. Harry Dexter White to the Secretary of the Treasury Morgenthau, when World War II was going on, that we should save our materials, or not produce them, and buy them from foreign countries. Also there was emphasis on buying them from Russia and loaning money to Russia.

With that memorandum as a basis, Secretary Morgenthau wrote to the President of the United States, Mr. Truman, and recommended that very program.

When the Congress passed the Stockpile Act in 1946, it included the Buy American clause for the reason that we could not transport raw materials over either ocean in time of war.

But when Mr. Truman, as President of the United States, signed that Stockpile Act, he took occasion to say in a public release that he very reluctantly signed the bill, because of the Buy American clause, and because of the emphasis on domestic production. And he took further occasion to say that it was not the policy of the administration to buy materials in this country, but it was to save these materials and buy them from foreign countries. This followed the lines of White's memo.

My personal opinion is that he never saw the Harry Dexter White memo and had no idea who had originated the idea. Nevertheless, it became effective.

Now, as a result, we find, in regard to many of these materials, that we are dependent on foreign shores, across one or both major oceans, for such critical and strategic materials and minerals.

You are in the National Defense Administration, so I will not try to advise you, Mr. Thomas. But the evidence is very conclusive that these materials would be unavailable within 24 hours after the beginning of an all-out war. The raw material used in titanium is being imported from India and Australia. In peacetime they have stopped the flow of rutile sands to this country. At any time they could stop the shipment of new material to this Nation, and simply force us into further agreements, through a mild form of blackmail. But the worst part of it is when a war really starts.

Now, as to manganese, we are getting 850,000 tons, the evidence shows, annually from India, which is half of our annual consumption. If a war breaks out, it will be impossible for us to get manganese from India. Not a pound of steel can be made without it.

Now, many of these minerals and materials are in the same category. And I want to say to you that evidence before the committee shows that the Western Hemisphere can be made self-sufficient in everything we need to fight an all-out war, with the possible exception of industrial diamonds. And evidence also showed that you could cut the use of industrial diamonds, due to improvements in that field, 50 percent. Also indications are very strong that you could get what you needed in South America, and could transport them readily by air. So stockpiles in industrial diamonds are not very difficult.

SELF-SUFFICIENCY

I think we are facing a situation where we must be in position to have going-concern industries in the United States. And, of course, we are charged with making recommendations that will bring about maximum production of these materials in our own country, the United States of America. And if it develops—and it would seem so at the moment—that the Western Hemisphere is the only dependable supply in case of an all-out war, it is necessary to make ourselves self-sufficient in the Western Hemisphere. It would not mean that in

peacetime you would not trade with everyone, but it would mean that over a 2- to 4- or 5-year program we would reach a position so that we could not be blackmailed either into a contract, a treaty, or a war, because we can take care of ourselves in the Western Hemisphere.

General, I need not say that I am gratified that you are to be consultant to this committee. I did not know you until we started the hearings, and I have been impressed wih your grasp of this subject. Would you like to add anything for the benefit of the committee?

General METZGER. Mr. Chairman, as you stated, I have had the privilege of attending, I believe, all of your hearings, or the hearings of your committee, and I feel that the activities of the committee, the objectives of the committee, have been highly constructive.

I feel that the pointing up of the necessity for titanium and for the supply of critical materials within the Western Hemisphere has been a very significant contribution to the security of this country.

I was particularly happy to hear you this morning mention the need for a titanium industry in being in this country, an industry which, to an extent, parallels the aluminum, steel, and copper industries. Because we in the military know only too well, particularly those of us who have gone through two mobilization buildups, that our capability to reach higher levels of production and to achieve higher rates of production rests upon the health of the civilian economy. Any material or metal which is only sufficient to support a peacetime level of production is a very dangerous material and metal for us in the military to tie our production designs to.

In each mobilization buildup, World War II and the Korean buildup, it was necessary to exercise controls and the allocation of such materials as aluminum, copper, and steel, in order that the defense programs could proceed toward their objectives.

I therefore feel that your remarks, Mr. Chairman, were most appropriate, and that titanium should take its place along with those materials, and that a commercial civilian development should be encouraged and that materials should be made available for the development of commercial applications and the further production of such commercial applications once they are proven.

I think it is essential to our mobilization capability should we ever be called upon to mobilize.

Senator MALONE. General, you have heard all of the testimony in the last 4 months. Also you have been in a position at Wright Field to have studied not only the production but the plans and the statements made by companies not yet in the business but who want to be in it.

Do you think there is a likelihood of a substantial reduction in price per pound of the sponge, or eliminating the manufacture of sponge and getting directly into the production of the metal itself?

General METZGER. I don't feel that the growth pattern of titanium costwise or technically will differ from that of any other material. We know that in 1920, I believe it was, magnesium ingot was selling for $5 a pound in ingot form. Five years later it was $1.60 a pound.

Senator MALONE. How about aluminum?

General METZGER. We have seen aluminum, going back to the historian's day, drop from $5.45 a pound to 19 cents a pound, over a period of a hundred years.

The reduction within the past 15 years has been phenomenal.

Senator MALONE. Is it not the history of every metal that when the demand is there and there is a profit incentive, the improvement in cost of production is almost phenomenal?

General METZGER. That is my opinion.

I think that is pretty generally the experience that American industry has had with all materials.

POTENTIAL GREATNESS

Senator MALONE. The statement has been made, General, and estimates have been made, that this new titanium metal, this miracle metal, or whatever you choose to call it, could easily be a five to ten billion dollar new industry in the Nation in the reasonably near future if these progressive steps, which you have mentioned, are taken. Would you say it could have any future of that kind?

General METZGER. I feel, and I am sure I am not alone, from the number of people within the industry with whom I have talked on the subject of titanium, that titanium offers a tremendous growth potential.

Senator MALONE. As a new industry?

General METZGER. As a new industry.

Senator MALONE. Civilian as well as military?

General METZGER. Civilian as well as military.

Senator MALONE. One thing I did not mention, but I think it is well-known: The testimony shows that when an airframe is designed to save 1 pound of aluminum, it may result in saving up to 8 or 10 pounds in the entire aircraft.

General METZGER. That is the rule, Mr. Chairman, that a pound of weight eliminated in basic design in the aircraft will permit 6 to 10 pounds reduction in weight of the total aircraft.

The reduction in weight of the aircraft itself could be absorbed in greater fuel carrying capacity and therefore longer range. It could result in higher speeds, or it could result in a smaller aircraft structurally, dimensionally, to accomplish the same mission, with the same specifications and characteristics of the aircraft presently in construction although of smaller size.

And pounds of aircraft mean dollars, and reduction in weight means a reduction in cost.

Senator MALONE. These planes of the future, the planes that we are now making, these bombers—if they reach a speed of seven or eight hundred miles an hour, they do need another metal, such as titanium, for the covering of the plane itself. Is that true?

General METZGER. Not only for the covering of the plane, Mr. Chairman, but the skin surfaces and control surfaces, and also for the structural members within the wings and fuselage. Because heat is generated there also. As has been brought out by most of the aircraft manufacturers in testimony, the aircraft in design stage at present, with speeds from Mach 2 to Mach 3½ will require material other than aluminum.

Senator MALONE. Aluminum softens under certain speeds.

General METZGER. Aluminum breaks down pretty badly in the neighborhood of 350° F.; that is, the aluminum alloys that we are using

today. And the program in aluminum has been under way for many years and has pretty generally reached fruition. We do not look for too many more improvements in aluminum alloys.

Senator MALONE. I want to say to you, Dr. Flemming, that I think you have done a very wise thing to bring in the Bureau of Mines. And we have used them in our work. I have known many people in the Bureau of Mines for 30 years. Of course, some of them are younger men and have less experience. But we find there is no substitute for the men who are specialists in their field. We find many reports, but there is only one reliable source of such information on minerals in the capital today, and that is the Bureau of Mines and the Geological Survey. Others may assume they know it, but they must finally go there and get the basic information.

I have regretted over a period of years that they were not given the buildup and the credit they deserve.

Mr. Wortman, of Boulder City, Nev., was sent there by the Bureau of Mines. He is the one who worked out some of the technical difficulties to make it possible to manufacture titanium through the sponge process now being used. He recently received a medal from Secretary McKay.

Now, Mr. Wortman is just like hundreds of other scientists, the men who have spent their years in laboratories. About all the reward they can ever get is that someone else, who is in a responsible position, speaks civilly to them. And to have a medal is quite an achievement. Certainly they get no money, as pay, in comparison to what they contribute.

So I have the greatest confidence in the men in charge of the Bureau of Mines.

As a matter of fact, I do not know your professor from Columbia, but he has able men working with him.

The general has been very kind in working with us.

We appreciate your presence here this morning, and if there is anything we can do to help you, we certainly shall.

Will you keep in touch with us?

Dr. FLEMMING. We will be very happy to.

Senator MALONE. We will recess to the call of the Chair.

(By direction of the chairman, the following is made a part of the record:)

GENERAL SERVICES ADMINISTRATION,
Washington 25, D. C., July 25, 1951.
GS-OOP(D) 12047

TITANIUM METALS CORPORATION OF AMERICA,
60 East 42d Street, New York, N. Y.

GENTLEMEN: 1. The United States of America, acting through the Administrator of General Services, proposes to enter into a formal contract with you which will provide for the production and sale by you of 18,000 short tons of titanium, hereinafter referred to as "additional production," to be derived from additional facilities which are hereinafter described and which you are to provide and operate for the purpose of producing such titanium under this order. Such production and sale shall commence with the production of the first pound of titanium from the additional facilities. After completion of the acquisition and installation of the additional facilities, with necessary improvements to present structures, the annual production shall be at the rate of approximately 3,600 short tons of titanium per year. By the acceptance of this order you undertake to bring the additional facilities to the point where they are capable of producing at the following percentages of the rated annual production of approxi-

mately 3,600 short tons: Twenty-five percent (25%) by May 1, 1952; fifty percent (50%) by June 1, 1952; seventy percent (70%) by July 1, 1952; one hundred percent (100%) by September 1, 1952; and thereafter at one hundred percent (100%). The additional facilities shall be deemed to be completed on September 1, 1952 or when said additional facilities are capable of producing approximately 2,900 short tons per year, whichever event first occurs.

2. The additional facilities hereinbefore referred to shall consist generally of the following: improvements, additions, and alterations of and to present buildings and other fixed installations at Henderson, Nevada; machine tools; furnaces; and other machinery and equipment. Such additional facilities will be subject to the approval of the Administrator prior to acquisition or installation thereof, and will be described with more particularity in the formal contract. The amount of expenditures for said additional facilities shall not exceed $15,000,000.00, including engineering expenses, construction expenses and fees.

3. The Government will advance to you, from time to time, as may be needed for the acquisition and installation of the additional facilities, with the necessary improvements, additions and alterations of and to existing structures, amounts which may total to but not exceed $15,000,000.00. All such advances will bear interest at the rate of four percent (4%) per annum on the unpaid balance, from the date of advancement.

4. Such advances, with interest thereon, will be repaid by you by the payment to the Government of poundage payments. Said poundage payments shall be made upon the production of each and every pound of titanium sponge produced from the additional facilities and shall begin to accrue with the first pound of titanium sponge produced from the additional facilities. It is understood that at the present time and in accordance with the technological processes now in use it is commercially necessary that titanium metal be first produced in the form of sponge prior to the production of ingot, strip, sheet, bar, wire, or other finished products, forms, shapes or sizes and it is further understood that there is a refining loss of titanium metal in reduction of sponge to other forms, shapes or sizes or end products. You agree that should technological processes change so it becomes unnecessary first to make sponge, the poundage payment shall be so based upon production of such other form or forms of titanium produced from the additional facilities as will preserve the interests of the Government as if the said poundage payment had continued to be based upon the production of titanium sponge. Said poundage payments shall, subject to the provisions of paragraph 10, be at the rate of $0.47 for each and every pound of titanium sponge produced from the additional facilities, and shall continue for ten (10) years from the date of completion of the additional facilities as defined above, or until all advances with all interest thereon are repaid, whichever event first occurs. Said poundage payments may be made in cash or by tender of titanium sponge and all such payments shall be credited first against the interest accrued to the date of payment and then against the unpaid principal. Such payments shall be made quarterly, or at such other time or times as may be in the future agreed upon by you and the Administrator. You may pay all or any part of the said advances, in cash or in titanium sponge, in advance at any time during the said period of ten (10) years, and interest shall thereupon cease upon the principal so paid. You may, in making any such payments in advance, specify, if you so desire, that such payment shall be deemed to be payment in advance of poundage payments to accrue in the future, and thereupon further poundage payments shall not again become due upon future production until a number of pounds of titanium sponge have been prodced upon which the poundage payments are equal to the payments so made by you in advance; and thereafter poundage payments shall again become due upon further production. Said advances by the Government and said poundage payments by you will be made under any such additional terms and conditions as the Administrator of General Services may prescribe.

5. (a) Commencing with the date when the additional facilities are capable of producing approximately 1,800 short tons per year and continuing until the termination or completion of this contract, and subject to priority delivery as may be required pursuant to law, the Government may require you to sell to it, or for its account, for the national defense, on thirty (30) days notice, all or any part of 100 tons of titanium in sponge or ingot form during each three-month period. Titanium sponge for the purpose of this contract is defined as follows: a porous form of titanium metal having sufficiently low impurity content (as

hereafter specified) to contain a pure titanium content of at least 99.3%, conforming to the specifications below. Ingots produced from said sponge shall be capable of being processed into commercially useful shapes and finished products.

CHEMICAL ANALYSIS

Titanium content: 99.3 percent minimum.
Impurities:
Iron: 0.25 percent maximum.
Nitrogen: 0.03 percent maximum.
The combined content of chlorides shall be maintained at the lowest minimum amount consistent with good commercial operation. The maximum limitation of chloride content shall be subsequently established by agreement between the contractor and the Government based upon operating and storage experience.
Total maximum impurities: 0.7 percent.
The hardness after arc melting in an inert atmosphere shall be less than 250 Vickers or 61 Rockwell A.

SAMPLING AND ANALYSIS

Sampling and analysis shall be conducted in conformity with methods and procedures established by the United States Bureau of Mines.

(b) It is understood that you intend, in connection with the additional facilities, to be able to deliver titanium in forms other than sponge or ingot, such as strip, sheet, bar, wire or other finished products, forms, shapes, or sizes, and the Government reserves the right upon your becoming able so to deliver to require the delivery to it of all such part of said 100 tons provided for in subparagraph (a) above per three-month period in any of such other forms, shapes, or sizes which you are able to deliver.

(c) After you have made titanium available for sale to industry as provided in paragraph 6 and have received and accepted orders thereunder, the Government shall have the right to require you to sell to it, or for its account, for the national defense, on thirty (30) days' notice, for each three-month period, all or any part of the amount of titanium by which the purchases of the Government under subparagraph (a) of this paragraph 5 and the purchases of industry under paragraph 6 fall short of 900 tons for said three-month period, provided, however, that sales made to the Government under this subparagraph (c) shall be, unless otherwise agreed by you, only in the form of strip, sheet, bar, wire, or other finished products, forms, shapes, or sizes other than sponge or ingot.

(d) Sales to the Government under the provisions of subparagraph (a) of this paragraph 5 shall be at the prices provided in subparagraphs (a) and (b) of paragraph 8. Sales to the Government under subparagraph (b) or subparagraph (c) of this paragraph 5 shall be at the prices provided by subparagraph (c) of paragraph 8.

6. The quantity by which the Government's purchases for any three-month period, in accordance with subparagraph (a) of paragraph 5 above, fall short of the actual additional production for such period, shall be offered and made available by you for sale to industry, in the form of sponge (which sponge may or may not, as you desire, be in strict accordance with the specification hereinabove set forth), or in ingot or in such other forms, shapes, or sizes as you may reasonably be able to deliver, at your lowest market prices in effect at the time of delivery.

7. While any portion of such advances made to you by the Government or of interest thereon remains unpaid, any quantity of the additional production not disposed of in accordance with paragraphs 5 and 6 and not otherwise sold or utilized by you may be tendered to the Government during each consecutive twelve-month period (the first such period to begin with the date when the additional facilities are capable of producing approximately 1,800 short tons per year). Such tender to the Government shall be in the form of titanium sponge only, and may not be in excess of 300 tons for delivery in any one month. The Government shall purchase, at the price provided in subparagraph (a) of paragraph 8, the amount so tendered. The Government shall not be required to buy under this paragraph 7, for any such twelve-month period, more than the actual output of the additional facilities during such period, less the quantity of such additional production disposed of in accordance with paragraphs 5 and 6 and otherwise sold or utilized by you. The Government shall pay for such sponge so tendered by crediting the value thereof, at the price set forth in subparagraph (a)

of paragraph 8, against the balance of your indebtedness for such advances and accrued interest thereon, such credit being first applied to accrued interest and then to principal. Upon repayment in full of your said indebtedness to the Government and accrued interest thereon, all rights of such tender of titanium sponge by your to the Government shall cease.

8. (a) The price for titanium sponge which you are required to sell to the Government under subparagraph (a) of paragraph 5 and which you may tender to the Government under paragraph 7 shall be the lower of $5.00 per pound or the average monthly market price for titanium sponge, for the month in which delivery of such sponge is made, quoted by the Engineering and Mining Journal, Metal and Mineral Markets, or such authoritative successor publication as may be agreed upon by you and the Administrator.

(b) The price for titanium ingot which you may be required to sell to the Government under subparagraph (a) of paragraph 5 shall be the price for titanium sponge to be sold to the Government as set forth in subparagraph (a) of paragraph 8, plus the average monthly market differential between titanium sponge and titanium ingot, for the month in which delivery of such ingot is made, quoted by the Engineering and Mining Journal, Metal and Mineral Markets, or such authoritative successor publication as may be agreed upon by you and the Administrator.

(c) The price for strip, sheet, bar, wire, or other finished products, forms, shapes, or sizes which you may be required to sell to the Government under subparagraphs (b) and (c) of paragraph 5 shall be the lowest price at which you deliver such form, shape, or size to any other entity, for the month in which delivery is made.

(d) The Government shall pay for the sponge, ingot, strip, sheet, bar, wire, or other finished products, forms, shapes, or sizes which you may be required to sell to the Government under subparagraphs (a), (b), or (c) of paragraph 5, after deducting from the appropriate purchase price as set forth above, the aforesaid poundage payment figured for each and every pound of titanium sponge so delivered, or used in the production of such ingot, strip, sheet, bar, wire, or other finished product, form, shape, or size.

9. In the event that any part or process of the new facilities shall become partially or wholly obsolescent, or in the event that any improvement in equipment or process is hereafter devised which is deemed by you to be advantageous, and if, incidentally thereto, replacement, acquisition, or addition of equipment or process is required, you shall have the right to apply to the Government for approval of such replacement, acquisition, or addition to such equipment or process. The Government shall have the right to approve or reject, in whole or in part, any such change in equipment or process recommended by you. In case the Government approves any such change, the Government will advance to you such supplemental funds as may be necessary to defray the cost of such change. Such supplemental advance will be added to the original advances, after deducting from said original advances the installed cost of the equipment or process so changed, less: (1) accrued accelerated amortization on such equipment or process so changed, at the rate set forth in the certificate of necessity which you have obtained from the Defense Production Administration; and (2) such other depreciation as may have been allowed by the Bureau of Internal Revenue for any part of the equipment or process so changed for which accelerated amortization was not authorized; and (3) all reasonably realizable value of the equipment or process so changed. Upon completion of the aforesaid calculation, the poundage payment per pound of titanium produced to be paid by you will be increased or decreased accordingly, to conform to the adjusted advance. The adjusted advance will bear interest at the rate of four percent (4%) per annum, as specified in paragraph 3 above. It is not the intention of the parties that any change will be made reducing the productive capacity of the additional facilities to less than 3,600 short tons of titanium per year, and no such change shall be made without the specific written authorization of the Government.

10. In the event that the total advances made to you by the Government under the provisions of paragraph 3 or paragraph 9, plus interest upon said advances figured for a period of five (5) years in the manner and at the rate specified in paragraph 3 above, shall not total the sum of $15 million, then the rate of poundage payments hereinabove in paragraph 4 set forth as $0.47 for each and every pound of titanium sponge produced from the additional facilities, shall be proportionately reduced and thence forth shall be paid as thus reduced upon each and every pound of titanium sponge produced from the additional facilities.

11. In the event that (1) decline in market prices, or obsolescence of any equipment or process as to which you reasonably request but do not receive the Government's approval for change, or lack of demand, result in the future in your inability to earn a reasonable profit from the operation of the additional facilities, and (2) you so demonstrate to the satisfaction of the Administrator of General Services, then you shall have the right to tender to the Government the additional facilities, with the exception of improvements, additions, or alterations of and to present buildings and other fixed installations; *provided, however*, that, coincidentally with such tender, you shall pay to the Government in cash the fair value of all such of said improvements, additions, or alterations of and to present buildings and other fixed installations as are useful to you. Upon such tender by you of such portion of the additional facilities, and upon payment by you of such cash in said amount, the Government shall accept such tender of all machine tools, furnaces, and other machinery and equipment which are a part of the additional facilities, and shall accept the payment of said cash in said amount. No payment by the Government to you shall be made, nor shall any liability of the Government to you arise, from or on account of or in connection with such tender or payment by you. Upon such tender of said portion of the additional facilities and payment of said cash, and upon acceptance of the same by the Government, your obligations to pay any then unpaid balance of the aforesaid advances and accrued interest thereon, shall cease; and the Government thereafter shall have a period of eighteen (18) months within which to remove, and within such period shall remove, at its own expense, all said machine tools, furnaces, and other machinery and equipment; *provided, however*, that the Government shall not be or become liable for the payment of rent or other charges for the use or occupancy of any space or buildings during said period of eighteen (18) months incidental to the storage and removal of such machine tools, furnaces, or other machinery and equipment.

12. In any event, and despite the provisions of parapraph 13 below, this contract shall terminate upon the occurrence of any one of the following, whichever may first occur:

(a) The production by you of 18,000 short tons of titanium sponge, coupled with the full repayment by you of all advances made to you by the Government, together with interest thereon;

(b) The full repayment by you of all said advances together with interest thereon, before the period of five (5) years shall have elapsed after the date of completion of the additional facilities, provided, however, that in such event the provisions of subparagraphs (a) through (d) of paragraph 5, the provisions of paragraph 6, and the provisions of subparagraphs (a) through (c) of paragraph 8 shall continue in full force and effect until the end of said five (5) year period;

(c) The expiration of ten (10) years from the date of completion of the additional facilities;

(d) The tender by you of the additional facilities and cash in the amount aforesaid to the Government, and acceptance thereof by the Government.

13. The time for performance by you of your obligations under the provisions of this order or the formal contract relating to the completion of the additional facilities, the operation of the additional facilities, or the production and delivery of titanium from such additional facilities, shall be extended at your option by a time or times equivalent to any delay, interruptions or cessations occasioned by force majeure (herein defined as any cause which is beyond your reasonable control and is not due to your fault or negligence, including, without limitation, acts of God, strikes, fires, storms, sabotage, acts of war or public enemy, and priority or allocation requirements or other acts of the Federal Government). The formal contract will set forth the time and manner of notices to be given by you of the occurrence and termination of each such force majeure.

14. All contract provisions presently required by Federal law, Executive Order, or applicable regulations to be included in contracts of the type herein described, are incorporated herein by reference, and will be set forth in the formal contract, as then required.

15. By the acceptance of this order you undertake to proceed without delay to purchase materials, make commitments, and conduct the operations necessary to produce such titanium. You also agree to enter into negotiations with the General Services Administration looking to the execution of a formal definitive contract.

16. Your acceptance of this order will be indicated by your affixing your signature to this letter and two copies thereof and mailing or delivering the executed original and one executed copy to the Administrator of General Services within ten (10) days from the date of this letter. Such acceptance will constitute this order a contract on the terms set forth herein.

17. This contract is entered into pursuant to the Defense Production Act of 1950, as amended (Public Law 774, 81st Congress; Public Law 69, 82d Congress), and the Federal Property and Administrative Services Act of 1949, as amended (Public Laws 152 and 754, 81st Congress).

UNITED STATES OF AMERICA,
By JESS LARSON,
Administrator of General Services.

Accepted, August 1, 1951:

TITANIUM METALS CORPORATION OF AMERICA,
By H. C. WILDNER, *President.*

Funds available, Date: 8/15/51.

M. SILVERMAN.

AUGUST 24, 1951.

TITANIUM METALS CORPORATION OF AMERICA,
60 East 42d Street, New York, N. Y.

GENTLEMEN: Under a letter agreement (hereinafter called the "Letter Agreement") between the United States of America (hereinafter called the "Government"), acting through the Administrator of General Services, and Titanium Metals Corporation of America (hereinafter sometimes called the "Corporation"), dated July 25, 1951, and accepted by you on August 1, 1951, the Government will advance to you up to $15,000,000.00. The Letter Agreement and the formal contract contemplated therein are hereinafter called the "Contract."

Paragraph 3 of the Letter Agreement reads as follows:

"The Government will advance to you, from time to time, as may be needed for the acquisition and installation of the additional facilities, with the necessary improvements, additions, and alterations of and to existing structures, amounts which may total to but not exceed $15,000,000.00. All such advances will bear interest at the rate of four percent (4%) per annum on the unpaid balance, from the date of advancement."

The pertinent parts of paragraph 4 of the Letter Agreement read as follows:

"Such advances, with interest thereon, will be repaid by * * * poundage payments. Said poundage payments shall be made upon the production of each and every pound of titanium sponge produced from the additional facilities (Supplied: actually total titanium production as present facilities do not produce titanium) and shall begin to accrue with the first pound of titanium sponge produced from the additional facilities. * * * Said poundage payments shall, subject to the provisions of paragraph 10, be at the rate of $0.47 for each and every pound of titanium sponge produced * * *, and shall continue for ten (10) years from the date of completion of the additional facilities * * *, or until all advances with all interest thereon are repaid, whichever event first occurs. Said poundage payments shall be made in cash or by tender of titanium sponge and all such payments shall be credited first against the interest accrued to the date of payment and then against the unpaid principal. Such payments shall be made quarterly, * * *."

In further implementation of paragraph 3 of the Letter Agreement the Government will make advances to your corporation upon your acceptance of the following additional terms and conditions:

1. The Corporation will maintain, in accordance with generally accepted accepted accounting principles, separate books and records of the costs incurred by you in connection with your obligations under paragraph 3 of the Letter Agreement and the disbursement of the funds advanced therefor. Such books and records, together with the supporting data, shall be retained while the Contract is in effect and for a period thereafter to be mutually agreed upon by the Government and the Corporation.

2. The Corporation shall maintain a separate bank account or accounts into which the advances made by the Government shall be deposited. It is not necessary that the accounts be maintained in the same bank. The Corporation may establish special sub-accounts as it sees fit for such purposes as machinery purchases, payrolls, et cetera.

3. The Corporation will not commingle such funds advanced by the Government with any other funds of the Corporation.

4. Each request for an advance shall be supported by a cash flow sheet showing the requirements of the Corporation for funds to be advanced. As the installation of the additional facilities progresses, the Corporation will also furnish a statement of cumulative costs in such detail as is acceptable to the Government.

5. The Government shall have the right to audit the books and records referred to in paragraph 1 above as well as those pertaining to the production of titanum sponge and shall have access to the Corporation's records at all reasonable times.

6. The Corporation shall obtain an agreement from Allegheny Ludlum Steel Corporation and National Lead Company, under which they will jointly and severally agree to act as surety for the Corporation in connection with the expenditure, in accordance with the provisions of the Contract, of the funds which are advanced to the Corporation under the Contract; and in the event any funds advanced should not be expended in accordance with the Contract the sureties will jointly and severally undertake forthwith to reimburse the Government for such expenditures.

The Corporation will also obtain from Allegheny Ludlum Steel Corporation and National Lead Company an agreement or agreements under the terms of which each agrees that, without the prior written consent of the Government, it will not sell, pledge or otherwise dispose of or hypothecate its interest in the Corporation.

7. The Government shall have a lien, paramount to all other liens, upon all property acquired or contracted for by the Corporation with such advance for the performance of the Contract, and upon the credit balance in the special bank account or accounts in which said advance may be deposited.

8. The Corporation will purchase and maintain insurance on the additional facilities in such forms and amounts as are satisfactory to the Government.

Paragraph 4 of the Letter Agreement provides that repayments shall be made quarterly or at such other time or times as may in the future be agreed upon by the Corporation and the Administrator. In order to implement this section and to provide for orderly liquidation of the advances, the following additional terms and conditions are prescribed:

A. The Corporation will keep records of the production of titanium sponge on a quarterly basis and shall on the first day of February, May, August, and November of each year furnish to the Government a statement showing the number of pounds of titanium produced in each of the quarterly periods ending respectively the last days of December, March, June, and September.

B. The Corporation will pay the poundage payment specified in the Contract as due to the Government, on the same days as it submits its statement of production.

C. The Government shall be furnished, on the same quarterly basis as provided in A above, a balance sheet which may be prepared by your own auditors; and the Government shall be furnished annually with a complete balance sheet as of the close of your fiscal year, prepared by an independent auditor. The balance sheet required herein shall be limited to the operation covered by this Contract.

Your attention is directed to that portion of paragraph 3 of the Letter Agreement which provides that interest on the advances is payable at the rate of four percent (4%) per annum. Interest shall therefore be accrued on each advance made and for each quarterly payment on the basis of a 365 (or 366) day year with varying numbers of days in each quarter.

If the rate of poundage payments is changed, as provided in paragraph 10 of the Letter Agreement, or if supplemental funds are advanced to the Corporation in accordance with paragraph 9 of the Letter Agreement, this agreement will be superseded by a new agreement conforming to the altered circumstances.

Please indicate your acceptance of the aforesaid terms and conditions by affixing your signature to the original and two copies hereof, and mailing or delivering to us the executed original and one executed copy hereof. An extra signed copy of this letter is enclosed for your retention. When you return to us your signed acceptance of these conditions you should also furnish us with the agreement or agreements required by paragraph numbered 6 above.

Sincerely yours,

MAX MEDLEY,
Comptroller, General Services Administration.

Accepted:

TITANIUM METALS CORPORATION OF AMERICA,
By H. C. WILDNER, *President.*

GENERAL SERVICES ADMINISTRATION,
EMERGENCY PROCUREMENT SERVICE,
Washington, D. C., September 16, 1953

Mr. J. S. ADLERMAN,
Interior and Insular Affairs Committee,
Senate Office Building, Washington, D. C.

DEAR MR. ADLERMAN: As requested by you in our telephone conversation yesterday afternoon, there are enclosed copies of contracts DMP–75 (Cramet, Inc.), DMP–6 (E. I. du Pont de Nemours Co.), and GS–OOP(D)–12047 (Titanium Metals Corporation of America). You will note that the Titanium Metals contract is in the form of a letter of intent, as it has not yet been reduced to a definitive contract.

The first two contracts are of recent date and the facilities are now under construction. No production has as yet been obtained from either facility. Titanium Metals Corporation of America attained first production of titanium metal from the Government sponsored facilities on October 13, 1951. There follows a tabulation by quarters of titanium metal production through July 31, 1953, the last date for which such figures are available:

	Tons		*Tons*
Dec. 31, 1951	25	Mar. 31, 1953	234
Mar. 31, 1952	60	June 30, 1953	247
June 30, 1952	71	July 31, 1953	79
Sept. 30, 1952	92		
Dec. 31, 1952	100	Total	908

Disbursements through September 30, 1953, will amount to $13,531,000.

Production from this facility has not been achieved as required by the terms of the contract. The matter has been followed continuously and the delay is attributable to technological difficulties encountered in adapting the results of pilot and prototype plants to the 10-ton-per-day scale of operation. We understand that approximately 275 tons will be produced during the quarter ending September 30, 1953, and more than 400 tons are expected to be produced during the fourth quarter.

If you require any additional information on this subject, it will, of course, be supplied upon request.

Very truly yours,

JOHN G. FORD,
Acting Chief, Contracts Administration Branch, Materials Division.

OCTOBER 20, 1953.

Memorandum to: Senator George W. Malone.
Subject: Titanium—Union Carbide Corp.

Mr. I. Stewart, vice president of Union Carbide introduced me to Dr. Augustus B. Kinzel, vice president of Electromet and president of Union Carbide Research Laboratories, Inc., and Arthur Lytle, director of research for Electromet.

According to Dr. Kinzel, Union Carbide is operating a pilot plant for the production of titanium at Niagara Falls, N. Y. Thus far they have produced 10,000 pounds of titanium. They are presently expanding their pilot plant to 4 or 5 times its present size. Dr. Kinzel stated that their process is their trade secret and that it differs from the Kroll process. He stated that he was at liberty to tell me that their process is essentially sodium reduction but one that is not vapor phased. It is an electrolytic process. It is a continual process except for one step. Union Carbide process does not require as much electric power and it goes directly from the salt to the metal production without any vacuum distillation.

In reply to my inquiry Dr. Kinzel stated that they had been negotiating with Mr. John Ford of General Services Administration, formerly of Defense Materials Procurement Agency, and he had also had discussions with a special Federal committee consisting of Dr. Francis Frary, Curtis, Hunter, and Long of the Minerals and Metals Advisory Board of the National Academy of Science. In their discussions with John Ford, Union Carbide proposed to put up a 10,000-ton capacity plant with their own money at a cost of approximately $40 million provided the Government would purchase their entire output for 5 years at the

price of $5 per pound sponge with a successive reduction on the price of 25 cents per pound per year.

Union Carbide have employed two consultants, Dr. Shipman, of Massachusetts Institute of Technology, and Dr. Walter Schlecten, of the Missouri School of Mining at Raleigh, Mo., who are willing to testify as to the worth of the process without divulging the process which they are bound not to disclose. They are willing to state that in their opinion the Union Carbide could produce the quantity and quality specified. They are willing to meet the present specifications set by the Air Force in Brinnell-hardness, etc. Ford turned down their proposition on the ground that the Government could not commit itself to the purchase of this sponge as too much money was involved. About the 15th of October Union Carbide made a second proposition in which it offered to the Government 20,000 tons of titanium at $5 per pound for delivery over a 5-year period or less and in the event that the Government did not buy this tonnage, the Government was to pay Union Carbide 85 cents per pound on the amount unpurchased. In return, Union Carbide would be willing to spend $40 million of their own money in building a plant without any Government loan or any other Government assistance.

According to Dr. Kinzel, Dr. Kroll had once worked for Union Carbide and the Union Carbide had the opportunity to accept the Kroll process. They rejected it on the ground that they did not think it was commercially feasible and they are still of that opinion. However, they stated that if they were called at a hearing, they would rather not be asked to express an opinion that the Kroll process, in their minds, is not satisfactory.

Electromet has a contract with Horizons, Inc., and an option on their process. Horizons, Inc., plant is located at Cleveland, Ohio, and their office is in Princeton, N. J. The president is Mr. Edwin T Goodridge, Horizons, Inc., Princeton, N. J., and the vice president is Mr. Frank A. Howard, 30 Rockefeller Plaza, New York. Horizons has two processes: One a so-called double fluoride process and another process called B process. The double fluoride process, in the opinion of Kinzel, was too expensive, and the B process, while cheaper than the double fluoride process, is still in the early stages of experimentation and the outcome is still uncertain. Electromet, according to Dr. Kinzel, is concerned over the estimates of the demand and to justify their heavy investment of over $40 million they would like to be assured that there would be a market for their production. He expressed keen interest in our hearings to be held in Los Angeles and stated that he would very much like to learn the opinions of the aviation industry on how much titanium they could use and at what price they could use it both for military and civilian planes. In response to what inquiries they had made as to other uses for titanium for the Armed Forces, he advised me that the Watertown Arsenal (N. Y.) under Colonel Meesick had expressed keen interest in the use of titanium in howitzer mountings, and their mobile units where lightness and strength are essential. He further stated that the Ordnance Department at Aberdeen Proving Grounds under General Simon had conducted some studies on armor plate and that the original reports on the use of titanium for armor plate were highly satisfactory, but that later tests were not up to par. As far as the Navy is concerned, although titanium is immune to seawater corrosion, the Navy did not feel that it would have any large-scale plans for titanium, since weight-strength ratio is not an important factor on vessels in view of the high price of titanium.

Dr. Kinzel was asked whether he knew of any other companies who were interested in titanium production. He stated he understood that New Jersey Zinc, of Palmerton, N. J. (Jerry Pierce, New York office), were conducting some research on the production of titanium, but he is not aware to what extent their research has gone. He also understands that Kennicut Copper (Cox, president, Jenness, engineer) have indicated some research interest in titanium. He is unaware of the exact extent. There is also a rumor that Dow Chemical is entering the field.

Dr. Kinzel called my attention to Imperial Chemical Industries, of England, who are reputed to have a sodium process and that they have entered into a 1,500-ton contract with the English Government in which the English Government has agreed to buy 75 percent of their production at the world market price.

I advised Dr. Kinzel and Mr. Lytle that undoubtedly they would be called to a hearing either in New York or Washington in the course of the next few weeks. They stated that they would be glad to attend to throw any light they could on the future of titanium.

OFFICE MEMORANDUM

To: Plans and operations.
From: MCPBS.
Subject: ANC daily report period: 1530 July 7, 1953–1530 July 8, 1953.

TITANIUM—DOUGLAS AIRCRAFT CO., INC.

(Unclassified) Douglas' decision to use titanium in the DC–7 nacelles is paying off even better than anticipated. The firewall and approximately 90 percent of the primary structural nacelle skins aft of the firewall are of the new high-strength, high temperature metal (titanium), and it represents the first time the material has been used in a commercial aircraft other than in token quantities. Two considerations entered into the decision. One was the desire to improve the strength against temperature characteristics of the engine nacelles. The other was to save weight. Douglas estimated a weight saving of 200 pounds per airplane. Actual saving is turning out to be between 280 and 300 pounds. This is equivalent to 1½ passengers for the entire life of the airplane, a revenue factor transforming the $20 per pound cost of titanium sheet into a bargain for the airlines. J. R. McGowan, chief project engineer, states that they expect titanium eventually to replace stainless steel and other alloy steels in many other applications in commercial airlines.

ROY A. WATKINS.

OFFICE MEMORANDUM

To: Plans and operations.
From: MCPBS.
Subject: AMC daily report period: 1530 July 8, 1953–1530 July 9, 1953.

TITANIUM TUBING

(Unclassified) What is probably the smallest size tubing ever drawn from commercially pure titanium has been produced at Superior Tube Co., Norristown, Pa. Outside diameter is only 0.0455 inch, and wall thickness measures 0.00225 inch.

ROY A. WATKINS.

ELASTIC STOP NUT CORPORATION OF AMERICA,
Union, N. J., November 21, 1953.

Reference: Elastic Stop Nut Corp. letter to R. A. Watkins, MCPB, dated November 21, 1953.
Subject: Use of titanium alloys in self-locking aircraft quality fasteners.

Elastic Stop Nut Corp. of America is initiating production of a line of self-locking nuts of aircraft quality at the request of two principal suppliers of fighter-type aircraft for the United States Government. The material specified is titanium alloy.

The design and development of titanium nuts at Elastic Stop Nut Corp. has been in progress for a period of several years on the same basis as has been successfully employed in providing high quality aircraft fasteners of conventional and specialized design for a period exceeding 20 years.

Production capacity is available to supply the needs of the aircraft industry for titanium nuts but only with an unusual expenditure of research, development, and production facilities relative to that which would be required for a similar development and production program in conventional materials.

The management of Elastic Stop Nut Corp. has expressed their willingness to undertake a development program for titanium fasteners with private funds in the interest of providing the most satisfactory product possible for the aircraft industry, but it will be appreciated if the following items can be clarified at an open hearing attended by the principals of the aircraft industry and the United States Government.

1. Is the use of titanium in aircraft being aimed at maximum weight-strength relationships and/or the excellent temperature and welding characteristics of this material?

2. What steps are being taken to disseminate service experience and research information on the use of titanium in aircraft?

(*a*) The problems of accelerated corrosion of titanium in association with dissimilar materials has not been made available to this company.

(*b*) Are initial programs for use of titanium fasteners in aircraft aimed at weight reduction or to obtain experience with production and service use of titanium? If the former is true, a careful screening of other materials such as high strength aluminum is required for most economic utilization of available titanium.

3. Have material priorities been established for present availability of titanium alloys? Will suppliers operate under the same priority as prime contractors if such a program exists or is in formation?

4. In order to conserve material and to make maximum use of the weight-strength advantages of titanium, nonconventional fastener configurations are required. Has the aircraft industry considered standardization on a 12-point nut of titanium rather than conventional hexagon nuts?

5. With the present scrap rates in processing titanium alloys, it is estimated that 2 to 3 pounds of titanium material will be required to save 1 pound of aircraft fastener weight. At the present price of material and the greatly increased cost of processing, is the Government and industry prepared to meet the required expenditures?

6. Exchange of information and research on the following topics is desired:

(*a*) Machineability indexes.
(*b*) Cold forming of titanium alloy.
(*c*) Tool clearances in machining and broaching.
(*d*) Forging temperatures.
(*e*) Cutting and antiseizing lubricants.
(*f*) Quality of material which can be expected.
(*g*) Types of successful tooling, carbide or cobalt high speed.

THE NEW JERSEY ZINC CO.,
New York 38, N. Y., November 17, 1953.

Senator GEORGE W. MALONE,
Chairman, Minerals, Materials, and Fuels Economic Subcommittee,
United States Senate, Senate Office Building,
Washington, D. C.

MY DEAR SENATOR MALONE: I duly received your telegram of the 10th instant informing me of the inquiry being made by your subcommittee to ascertain the potential demand and value of titanium metal in order to determine whether a more intensive effort should and can be made to increase production and reduce cost of this material, and inviting me to appear at a hearing on November 25 to present my views on these matters.

Our activities in the field of titanium have not included studies on the present and potential applications of the metal. We are a minority partner with Kennecott Copper Corp. in the Quebec Iron & Titanium Corp. in the production of titanium-bearing slag. That project, however, was founded on the purpose of supplying slag as a raw material for the production of titanium pigments. If and when the production of titanium metal becomes substantial, of course, Quebec Iron & Titanium Corp. will be an important source of raw material for the metal also.

Our own investigations and studies have been directed to the development of a more efficient and more economical method of producing ductile titanium metal, but that work is still in the laboratory stage. We have assumed, largely from material published by the Government and others and from our general knowledge of the situation, that there is a large potential market for such a metal at reasonably low cost, though we have not made any studies to determine the extent of such market, present or potential.

In these circumstances, it appears that I have no real information that would be helpful to you in pursuing the objectives indicated in your telegram. Our position was explained to Mr. Holderer by Mr. Newall W. Ellison, our counsel, today, and pursuant to that conversation, I understand that you will not expect me to appear before your committee on the 25th.

Needless to say, if you should find in the course of your investigation that there is some phase of it on which I might be of assistance to you, I will be wholly at your service.

Very truly yours,

C. H. GEORGE, *Vice President.*

NATIONAL RESEARCH CORP.,
Cambridge 42, Mass., November 17, 1953

Hon. GEORGE W. MALONE,
United States Senate Office Building,
Washington D. C.

DEAR SENATOR MALONE: In reply to your telegram of November 10, I will be very glad to appear before the Minerals, Materials, and Fuels Economic Subcommittee on November 25 at 10 a. m. in an effort to assist you in the study of problems associated with the increased production and reduced cost for metallic titanium.

Activities of National Research Corp. in the titanium field are directed primarily toward the development of new processes for the production of titanium from titanium-bearing ores. For some years we have also been concerned with melting and casting of titanium and titanium-rich alloys and small-scale production of shape castings of titanium. All of our work relating to the development of new commercial processes for titanium production, which was initiated in 1944, is now undertaken on a partnership basis with Monsanto Chemical Corp. Programs of both of our organizations in this field represent a substantial portion of our respective research activities and these have been undertaken at our own expense without any Government assistance.

Very truly yours,

RICHARD S. MORSE.

CURTISS-WRIGHT CORP.,
Wood-Ridge, N. J., February 5, 1954.

Hon. GEORGE W. MALONE,
Chairman, Minerals, Materials, and Facts Economic Subcommittee,
Committee on Interior and Insular Affairs, Senate Office Building,
Washington, D. C.

DEAR SENATOR MALONE: With reference to my testimony before your committee, I believe the thermal barrier begins to cause trouble with aluminum at approximately 900 miles per hour and that titanium is superior in that it is good for use up to speeds of 2,500 miles per hour.

Our best estimate of the requirements for titanium in the near future for the 5 engine companies in the United States is a minimum of 6,000 pounds per month.

Respectfully,

ROY T. HURLEY.

DEPARTMENT OF THE AIR FORCE,
OFFICE OF THE SECRETARY,
Washington, September 17, 1953.

Hon. GEORGE W. MALONE,
United States Senate.

DEAR SENATOR MALONE: I refer to your recent inquiry concerning the electric power requirements for processing and producing titanium.

Typical power requirements for producing titanium based upon the Kroll process are 20 kilowatt-hours per pound of titanium sponge. Overall power requirements to produce the finished ingot is approximately 26.4 kilowatt-hours per pound. This figures includes total plant-power requirements. The process used by the Titanium Metals Corp. and Du Pont is the Kroll process or proprietary modifications thereof. The attached chart serves to demonstrate one of these processes. It should be noted that of the 20 kilowatt-hours necessary to produce the titanium sponge a substantial portion is used in the reduction of magnesium. Magnesium requires about 10 kilowatt-hours per pound.

There are many other proposed methods for producing titanium. Most of these proposals are based either upon further modifications of the Kroll process or the electrolytic method. Although there are no facilities producing titanium by the electrolytic method, it has been estimated the power requirements will be from 10 to 15 kilowatt-hours per pound of sponge, depending upon the particular variation of the electrolytic method that is employed. This figure is exclusive of power requirements of the plant, such as heat and light.

A number of other different reactions have the possibility of producing titanium. The individual reactions represent variations of the basic processes of thermal decomposition, chemical reduction, and electrolytic reduction in fused salt of organic media, of various titanium compounds—oxides, nitrides, sulfides, and halides.

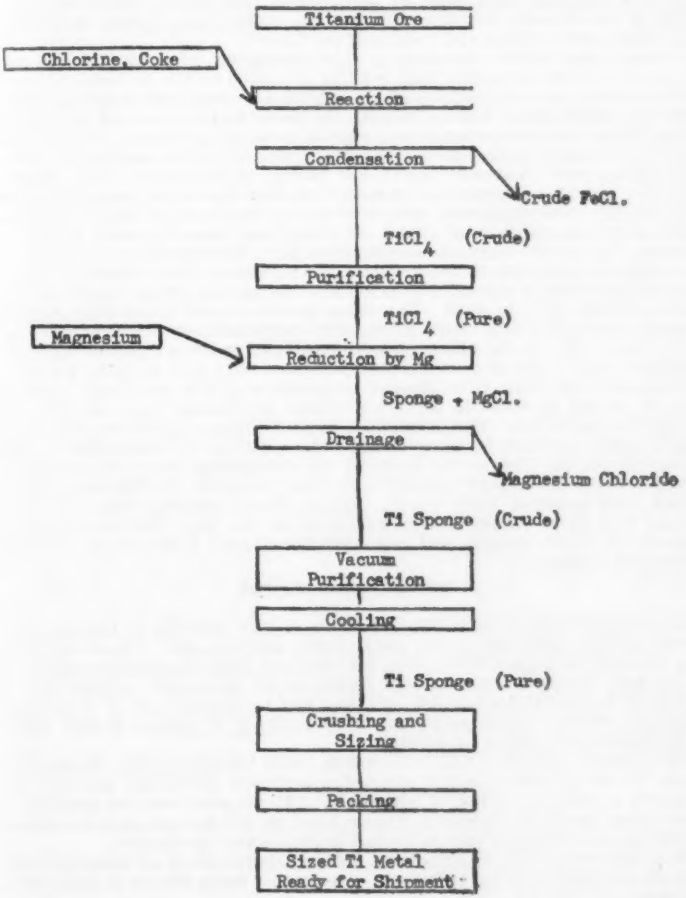
We do not know how many processes have been proposed to the General Services Administration, but we are informed that the following companies are interested: Kennicott Copper Corp., Kaiser Aluminum & Chemical Co., Union Carbide & Carbon Co., Horizon Titanium Co., Monsanto Chemical Co.

It is a pleasure to provide you with this information.

Sincerely yours,

JOE W. KELLY,
Brigadier General, USAF, Director, Legislative Liaison.

FLOW SHEET - TITANIUM METAL



Structural Considerations and Applications for the Use of Steel and Titanium Alloy Extruded Shapes in Modern Aircraft

By Keith A. Wilhelm, Production Design Engineer, Lockheed Aircraft Corp., California Division, Burbank, Calif.

Summarizes structural requirements leading to use of high-strength materials, including metallurgical and physical properties. Discusses application of steel and titanium extrusions and points out problems to be faced in production, fabrication, and assembly.

The fiftieth anniversary of the first powered heavier than air machine is being celebrated with the usual rash of speculations and predictions concerning the future of the aircraft industry and the remarkable sizes, shapes, and performances of aircraft missiles and rockets of the future.

It seems appropriate therefore in this atmosphere of appraisal and prediction to discuss the structure that is being propelled so far, so high, and so fast, and to examine the applications of hot extruded ferrous and titanium alloys.

By way of definition and to indicate the scope and compass of the structure, weight is a useful perameter to use, especially since the success of any aircraft is so fundamentally tied to its weight. The structural weights of over 60 types of aircraft in service today are shown in Figure I. This weight by definition, includes the entire airframe, including the wings, body, tail, landing gear, controls, and supporting structure but excludes power plant, instruments, trim equipment, and "useful load." It is obvious that structural weight is an important part of the aircraft, ranging from 22 to 46% of the total weight. This percentage of structure to total weight is increasing; for instance, in the last 15 years for fighter aicraft the structural weight to gross weight ratio has increased from 30% to 42%. The same growth occurs to varying degrees to bombers, transports, and other types. The importance of the structural weight is, of course, due to its effect upon the ratio of gross weight to load weight (military load in the case of fighters, bombers, etc.) and in turn, its effect on performance, especially if configuration, power, and fuel are fixed. This latter effect is shown in Slide II for a supersonic interceptor type aircraft having nominal excess thrust. The severe loss in performance characteristics resulting from a slight increase in gross weight (the resultant of structural weight increase) points out clearly the necessity for minimizing structural weight.

Basically the problem of aircraft structural design is no different today than it was when powered flight began. The airframe structure must be just the amount that is necessary and sufficient to do the job. To the fundamental problems of safety, weight, and cost have been added a few which result from higher performance.

ELEVATED TEMPERATUBE

One of the demands upon the structure of any aircraft is that it shall be strong, durable, and light in its temperature environment. Those areas which were exposed to higher than room temperature heat applications have, up to the present time, been adequately protected by ingenuous cooling, by minor reductions in material allowable stresses, and by limited use of heat-resistant materials. These compromises generally resulted in minor weight penalties but introduced few major complications.

The problem appears not to be so simple much longer however, because at the speeds for which new aircraft are being designed the entire aircraft is submerged in a boundary layer of heated air. The temperature rise resulting from these higher speeds is plotted in Figure 3 and it will be seen that as speeds are pushed upward, the structure is bathed in very warm air indeed.

The chief concern to the structural designer is the effect of elevated temperatures on materials and on structure. Among the many effects of high temperature are—

On the material

Hot strength at temperature
Hot strength after long time exposure to elevated temperature
Cold strength after various exposures to elevated temperature
Corrosion protection during and after exposure to elevated temperature
Creep properties (temperature and/or load intermittent)

On the structure

Distortion of aerodynamic contour due to nonuniform heating
Strength and stiffness under nonuniform temperatures
Overall strength and stiffness at high temperatures
Plus many variants of the above.

A considerable quantity of data is available so that, in general, account can be taken of the change in physical properties of the material at elevated temperatures and, as will be discussed later, there are a number of fine materials which have comparatively high strength/weight efficiency at elevated temperatures. It is true, however, that at any appreciable temperature above room temperature, all other things being equal, the structure must be heavier than would be necessary and sufficient for normal temperature environment. It is proper to say then that the effects of elevated temperature are assuming an ever increasing importance in aircraft structure.

STRUCTURAL FATIGUE

A phenomenon which has assumed a growing importance in aircraft design is structural fatigue. This has come about as a result of the steady reduction of conservative factors in design, the increased utilization of modern aircraft in terms of service life and loading and in the exploitation of new and stronger materials. The fatigue properties of these materials, however, generally have not increased proportionally with the improvements in static physical properties. The higher strength alloys in many cases, have shorter service life when designed to the same static strength than weaker materials. It may well be that higher tensile properties often will not be fully exploited in structures loaded repeatedly in tension, and this means that this consideration will necessitate added structural weight above the amount that would otherwise be optimum. Fabrication methods producing residual tension stresses are being avoided by hot forming and by other means because such stresses can result in fatigue difficulty even in members whose service loading is normally compressive.

STRUCTURAL RIGIDITY

In the past, aircraft structures have generally been designed for certain strength levels, and the stiffness of the structure that resulted has usually been adequate. Occasionally some added weight has been necessary to provide increased stiffness over and above that inherently present, but these have been exceptional cases. Hence, it may be said that strength considerations dictated the weight of the structure. Higher speeds, thinner wings, stronger materials and design refinements have altered this situation necessitating more and more attention to stiffness consideration. While flexibility is not always undesirable, it usually has undesirable effects. Provision of this additional stiffness for minimum weight generates a new and interesting structural problem. The cardinal principle of structural design, that to provide maximum strength for minimum weight the stress should everywhere be constant and as high as possible, does not apply in the case of design for a maximum stiffness to weight ratio. This is illustrated in Figure 8, for the simple case of a varying twist on a tapered tube with varying wall thickness. It will be seen that the optimum distribution of thickness for this tube differs depending upon whether the criterion is strength or stiffness. Since there are always requirements for strength, the structural designer must provide the structure which has both the necessary strength and stiffness but least weight.

STRUCTURAL MATERIALS

Having discussed a few of the structural phenomena, some of the techniques and methods available for efficient structure design, it is now in order to speak of the structural materials available. Figure 14 shows a rough historical record of the specific strength of the principal aircraft structure materials over the past 50 years. At the beginning wood was the optimum material for air frame construction and it has been used very successfully in many airplanes since. This is logical because it compares favorably on a strength weight ratio basis with some of the modern metals. However, wood fell by the wayside because of the inviolable law that the aircraft must be as large as possible on the inside and as small as possible on the outside; volume considerations alone have precluded wood in high performance aircraft. This fundamental demand for the structure to occupy as small a space as possible is once again bringing about an important

change in construction methods and materials as wings become thinner and loads become greater. Figure 15 shows the distribution by weight of the principal materials in a current fighter type airplane. Here it will be seen that aluminum alloys in structural applications is roughly ⅓ of the weight empty, or about 75 percent of the structure itself. A very similar distribution is found for transports and bombers. Yet a significant fraction of the structure is composed of other materials and this must be included in any discussion of structural materials. Figure 16 presents the specific tensile strengths of the principal structural materials available for aircraft structures. Some of the materials shown have been in use for some time.

Structure in the airframe is loaded in compression as well as in tension, and a comparison of materials must be made for this condition. Figure 17 shows a comparison based upon assumptions of optimum configurations, and indicates that in the high loading range high heat treat steel and titanium alloys compare favorably with high strength aluminum alloys.

INTEGRALLY STIFFENED STRUCTURES

A development in the utilization of aluminum alloy has been the integrally stiffened structure. This development has been as a result of a demand for simplified low weight/high strength structure, higher loads and more compact structures presage an increased use of this technique. The inner wing, box beam, lower surface of the Constellation airplane serves as an example to illustrate this type of structure. A comparison of some of the features of this structure with the conventional structure which it replaced can be seen in Figure 19. The important structural advantages are: improved fatigue properties, reduced shear lag and simplified sealing. Important fabricating methods, such as roll forging, progressive forging, and extruding, hold promise of even more economical production of similar structures. There are many other applications of integrally stiffened design which could be cited, but let it suffice to say that this type of construction is a powerful tool for structures of high performance aircraft.

HIGH HEAT TREAT STEEL

In the field of aircraft steels, the utilization of extremely high tempers has been deterred in the past by the fear of reduced ductility, impact resistance, and fatigue life, as well as increase in fabrication difficulties; however, experimental work on SAE 4340 steel at the highest level at which it could consistently be tempered, shows that while there is some reduction in ductility and impact compared to previously used tempers, these qualities are still quite satisfactory and there is a large spread between yield and ultimate tensile strengths, which feature is helpful in stress redistribution. Figure 20 illustrates this. It also shows that the notched endurance limit in percent of ultimate tensile strength is superior at the high heat treat level, and this means that at this temper the material when fully exploited in static tension will give as good service life as structures similarly designed at lower heat treat values. Fabrication difficulty has been increased but still lies within the practical range. This material promises to afford substantial gains in bending and tension applications and as loading intensities increase and structural space decreases applications of this material in compression structures are likely to prove efficient.

TITANIUM

Earlier in this discussion the problem of temperature effects on the structure was cited. It has been said that the temperature problem is the next big hurdle for high speed flight; analogous to the so-called sonic barrier. One material which offers much to the solution of the difficult task of providing strength/weight efficiency at elevated temperatures is titanium. Having remarkable resistance to corrosive attack and excellent properties at elevated temperatures, titanium is a highly attractive structural material. Figure 21 presents the basic physical properties for commercially pure titanium sheet at the temperatures for which titanium appears applicable. Figure 22 shows one of the many titanium alloys, Rem-Cru R0130A where the tensile strength/density factor at temperatures up to 1000°F is shown and compared to several other materials. Based on this simple criterion, titanium is the most efficient structural material for a very wide range of temperatures and has a strength/weight ratio at moderately high temperatures comparing favorably with that for the more

common materials at room temperature. The tensile properties of two other titanium alloys are shown in Figure 23 and 24 illustrating some potential aging and tempering possibilities as well as some interesting combinations of strength and ductility.

FUTURE MATERIAL POSSIBILITIES

Ingenuity and material development and adaptation have resulted in a list of materials available to the structural designer such as never before in history. Only a few have been touched upon in this discussion. Many other materials with attractive structural properties are likewise currently at hand. Important developments are underway leading toward the utilization of still others such as ceramics and sintered carbides. Nuclear physics reveals that materials as we know them consist mostly of empty space while the nucleus itself is packed with mass at the fabulous rate of approximately two billion tons per cubic inch so that untold strength may some day result when we determine the secrets of atomic binding. (Fig. 25.)

The foregoing discussion has touched on some of the problems involved as far as structural design is concerned. Mention was made of some of the general methods and materials available to make possible efficient structural design. A general summary therefore is in order which points up the following: Good structure, incorporating resistance to elevated temperature, light weight, rigid and strong, and requiring a very minimum of space, yet producible within a reasonable cost, requires the use of higher strength materials in the most efficient manner. I would be deligted at this time to propose that the hot extrusion of steel and titanium alloys is the panacea of all the problems confronting the designer—unfortunately it isn't; but to some extent, this method does offer a great percentage of the answers. Within the limitations of materials at hand and in anticipation of a reasonable amount of improvement in powered flight, the use of steel and titanium extruded to complex shapes will result in light weight, strong, efficient structure. As pointed out before, the concept of integrally stiffened structural panels has proved to be advantageous. In fact to the extent that one particular airplane now using this type of aluminum alloy structure could not be redesigned with conventional structure and still carry the loads for which it is now designed. The same aircraft could however be redesigned to use high heat treat steel or high strength titanium alloys and perhaps utilize the inherent qualities of these materials with a resultant saving in weight and improvement in structural efficiency. However any such redesign would have to take into consideration the fabrication and production problems involved in the use of these high strength materials. Structural parts now machined from plate stock of aluminum alloys cannot practically be machined in a similar fashion from high strength steel or titanium, that is if we consider cost as a criterion of practicality.

At this point I will discuss in review the application of hot extrusion of steel and titanium alloys for the airframe structure and will point out how this prime fabrication process may solve, to a degree, the problems raised by structural temperature, weight, and other considerations.

Weight

By the use of extrusions, the highest possible degree of structural efficiency can be obtained. The right amount of material at the right place can more easily be achieved by extruding than by any other of the common fabrication methods. Sharp fillets, undercuts, thin and thick adjacent areas all are possible and convenient to the extrusion technique. The elimination of forging draft, machine cutter radius allowances, sheetmetal bend radii limitations, and excess material to provide for attachment by welding or mechanical fasteners, lead to lighter weight structure and consequently to better performing airplanes.

Temperature

The use of extrusions to provide more efficient structural design coupled with the ability to produce efficient and desirable shapes from temperature-resistant materials is a most important tool to meet the problems encountered at elevated temperatures. Distortion due to nonuniform thermal expansion can be minimized through homogeneity of structure, i. e., skin stiffeners and beam members can be produced from identical materials and in many cases in one piece. This attractive feature not only reduces the problem of thermal conduction but also provides heat-resistant structural materials impractical to produce by other processes.

Structural fatigue

Extrusions of steel and titanium so far produced exhibit fatigue properties at least as good as comparable bar and rod and considerable improvement over forging. More important, however, to fatigue life of the airframe itself is the virtual elimination of stress concentrations occasioned by the "bits and pieces" construction of earlier conventional design. The trend toward larger structural components, panel-type structures further reduce this main problem of fatigue. In addition, such a design concept goes far to reduce the complexity of structures and the complexity of stress analysis to determine fatigue life of aircraft components.

Structural rigidity

The trend toward stiffer and stronger structure, especially in wing design, produces one of the most interesting applications of extrusions. Referring again to Figure 8 for the simple case of a linearly varying twist on a taper tube with variable wall thickness, we can readily see that an ideal structural shape would consist of a wide profile extruded panel with converging and varying skin thickness. Such an extruded shape is not only desirable but is within the development stages of production. Insofar as structural rigidity is concerned, there is also an important class of phenomena involving structural flexibility where the rate of deformation with time is the significant factor. These transient or dynamic phenomena are generally a problem on larger, more flexible aircraft and are generally accented by thin wings, large overhanging masses such as cells and wing tips. There is well-founded belief that use of a rather dense highly efficient type of skin structure such as that which could be achieved by extruding, will be the simplest and most effective answer to the problems arising.

Structural materials

The toughness and hardness of the materials which must be considered precludes the economic fabrication of these materials by the conventional methods of rolling, forging, drawing, or machining. Extruding not only is the last resort but, indeed, is an economical means of producing to a desired shape those materials which are virtually impossible to produce by any other means. There is no doubt but that the problems involved in straightening, forming, heat-treating, and processing will be no more difficult for extruded products, but may actually be simplified by the use of extrusion.

Assembly

The elimination of fasteners, the effective use of materials, the reduction in number of parts, and the inherent integrity of extruded shapes, panel sections, and other forms of structure opens wide the field of application for the hot extrusion process. The use of extrusion fulfills our requirement that an air frame structure must be as small as possible on the outside and as large as possible on the inside.

Throughout the discussion which has taken place today, we have mentioned cursorily the use of high heat-treated steels in aircraft structures and we have pointed out that hot extrusion is a suitable method for producing desirable shapes from these same high heat-treated steels. I feel that it is in order to outline very briefly some of the research which must be done before we are "in bed" with these materials.

1. BASIC PROPERTIES AND PROCESSING

(*a*) *Hydrogen embrittlement.*—It is recognized that, in general, the adverse effects of hydrogen absorbed into steel during cleaning and plating operations increases with increasing strength and increasing carbon content; consequently, methods of evaluating and controlling hydrogen embrittlement will constitute a major area of investigation.

(*b*) *Fatigue.*—The behavior of high-strength steel under alternating loads is of prime importance in design and application, since full utilization of increased tensile strengths cannot be realized if fatigue properties do not correspondingly increase.

(*c*) *Heat treatment—Effect of microstructure on properties.*—Proper heat treatment is mandatory to obtain optimum properties in high-strength steels. Many phases of heat treatment and its effect on properties must be studied in order to control microstructure, especially insofar as it affects properties at elevated temperatures.

(*d*) *Impact properties.*—As the strength level of steel increases, the toughness as revealed by notch bar impact tests generally decreases. Most steels exhibit a toughness minimum at tempering temperatures close to 500° F. This phenomenon, and the impact behavior of steels at low temperatures must undergo thorough investigation.

(*e*) *Static notch bar properties.*—There has been increasing interest in the use of static notched bar tensile tests as a means for evaluating structural integrity of steels. As the tensile strength of steel increases, the notched strength may actually decrease due to restriction of plastic flow in areas of stress concentration.

(*f*) *Creep and stress structure.*—The ability to withstand constant high stresses and to resist growth (creep) under high loads will be important factors in the utilization of the high strength steels.

(*g*) *Transverse properties and properties of heavy sections.*—It is recognized that properties of steel in large sections may be different from those measured by testing specimens from small bar stock. Directional properties transverse versus longitudinal also become important at high strength ranges.

(*h*) *Shot peening.*—Extensive use of shot peening as a method of improving fatigue properties of high strength steel parts and in preventing or reducing the effects of hydrogen embrittlement must be studied. Along the same line, the effect of shot peening when used as a forming method must be investigated.

(*i*) *Design properties.*—In addition to tests such as fatigue, impact, etc., to establish structural integrity, and processing studies to develop optimum heat treatment, surface treatments, etc., structural properties used directly in the design of parts must be established.

2. STUDY OF FABRICATION METHODS

Because of the high hardness involved, extensive investigation must be made to establish proper machining, grinding, forming, welding, and mechanical fastening techniques to utilize high strength steel products.

(*a*) *Machining.*—The machining of high heat treat steel has presented problems not usually associated with the lower strength levels. Proper design of equipment and tooling, as well as determination of optimum feeds and speeds as well as the effect of machining operations on properties must be investigated.

(*b*) *Grinding.*—Grinding may often be the only practical method by which high strength steel parts may be reduced to final dimensions. Because of increased susceptibility to stress cracking in the highly hardened steels, special techniques must be evolved.

(*c*) *Forming.*—Techniques involving the forming of high heat treated steel products may be similar to some degree to the techniques involved in forming aluminum without the advantages of forming a precipitation hardening type of material. Extensive investigation and development of equipment for stretching, rolling, drawing, forming must be conducted.

(*d*) Exacting control of welding times temperatures and materials must be established to produce satisfactory high strength welds. Much research work will be required for spot, flash, and pressure welding techniques.

3. TESTING OF COMPONENTS AND SERVICE EXPERIENCE

Service experience on parts heat treated above the 260,000 psi level is nonexistent. Adequate testing means must be developed to predict service life and as is always the case, the final and most important phase of the development in the use of a new material of this nature is the testing of parts under simulated service conditions.

4. STEEL COMPOSITION FOR USE AT HIGH STRENGTH LEVELS

Whereas 4340 (nickel-chromium-molybdnum) has been used in the majority of cases for structural parts at strengths in excess of 200,000 psi, strength levels now are being pushed toward the 300,000 psi ultimate range and several other alloy steel grades are being evaluated for these applications.

(*a*) *High silicon steels.*—Raising the silicon content of alloy steels increases resistance to tempering allowing the use of relatively high temperatures with high strengths.

(*b*) *Modifying 4300 series composition.*—This nickel-chromium-molybdnum-steel alloy series exhibits ductility and toughness at high hardness levels generally superior to most of the other standard analyses. Some steels being investigated generally involved additions of silicon, titanium, and boron.

(*c*) *Boron steels.*—As a means of conserving critical alloying ingredients special steels containing reduced amounts of nickel-chromium-molybdnum but with boron added to restore hardenability have been developed as potential alternates for standard grades. The three most important steels of this nature are the 98B40, 4340 with Boron and 86B45.

(*d*) *High carbon steels.*—Some investigation is in order on alloys such as 4350 and 4360 to evaluate the possibility of using isothermal heat treatment to obtain the 260 to 280,000 psi range and to explore the higher strength levels which the relatively high carbon content steels are capable of obtaining.

(*e*) *Rare earths.*—A study of the effects of rare earths on high strength steels is being conducted.

Many of the items thus outlined are being investigated at present. Some of them will require more extensive investigation than is presently anticipated. None of the problems are insurmountable; we were able to solve the problems involved in extruding hot steel through steel dies and there is no reason at all to believe that we cannot solve these.

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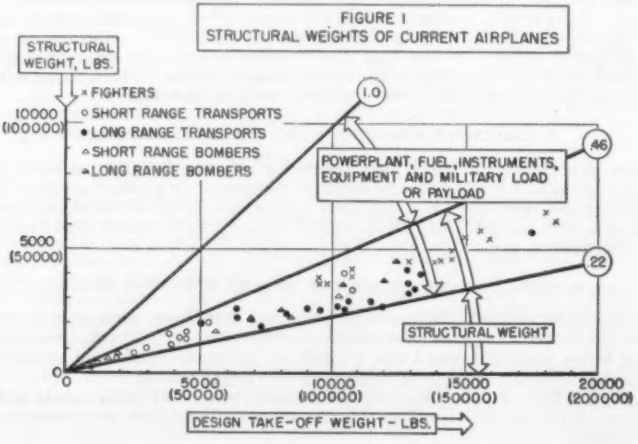
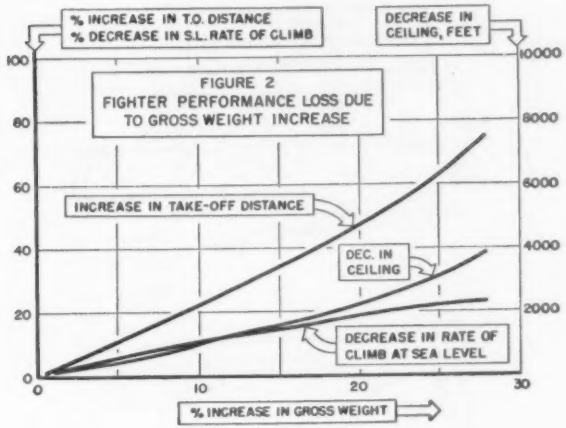
FIGURE 1
STRUCTURAL WEIGHTS OF CURRENT AIRPLANES




% INCREASE IN T.O. DISTANCE
% DECREASE IN S.L. RATE OF CLIMB
DECREASE IN CEILING, FEET
FIGURE 2
FIGHTER PERFORMANCE LOSS DUE TO GROSS WEIGHT INCREASE
INCREASE IN TAKE-OFF DISTANCE
DEC. IN CEILING
DECREASE IN RATE OF CLIMB AT SEA LEVEL
% INCREASE IN GROSS WEIGHT
100
80
60
40
20
0
10000
8000
6000
4000
2000
0
10
20
30

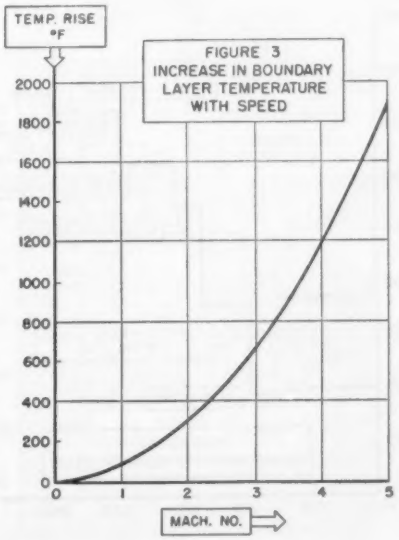
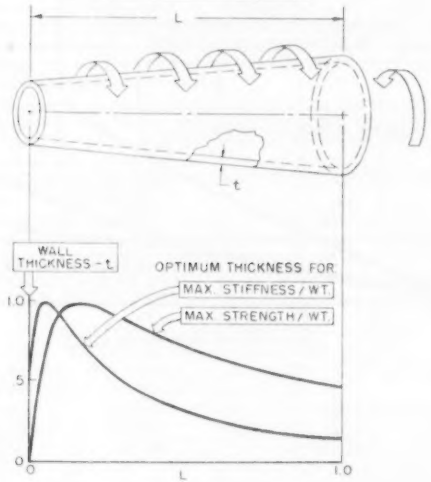

TEMP. RISE °F
FIGURE 3
INCREASE IN BOUNDARY LAYER TEMPERATURE WITH SPEED
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
MACH. NO.

FIGURE 8
OPTIMUM WALL THICKNESS
IN TAPERED TUBE



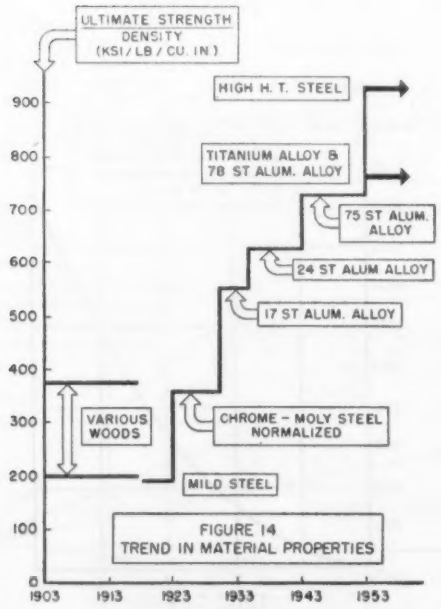
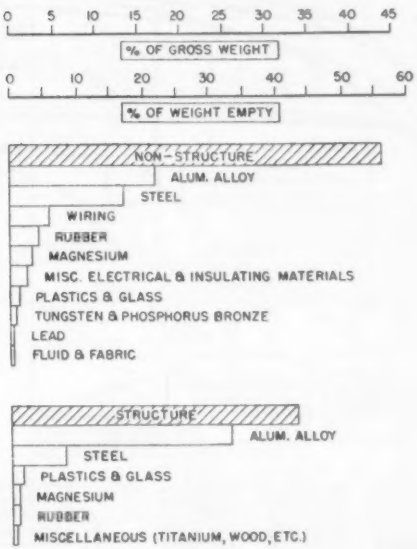


FIGURE 14
TREND IN MATERIAL PROPERTIES

FIGURE 15
DISTRIBUTION OF MATERIALS
BY WEIGHT—FIGHTER TYPE



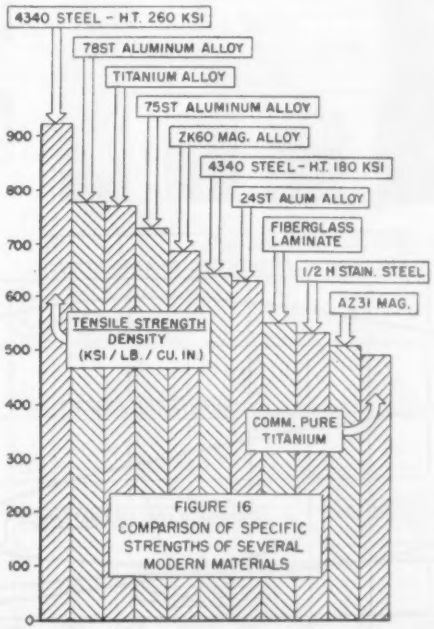


FIGURE 16
COMPARISON OF SPECIFIC
STRENGTHS OF SEVERAL
MODERN MATERIALS

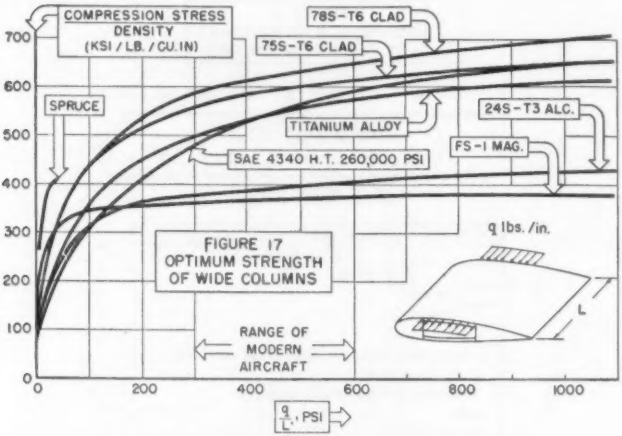


FIGURE 17
OPTIMUM STRENGTH OF WIDE COLUMNS

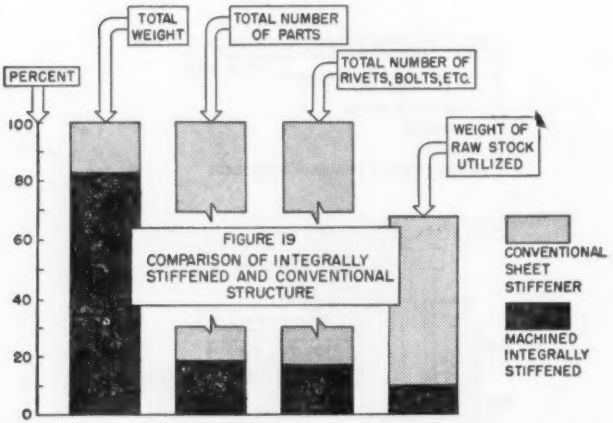


FIGURE 19
COMPARISON OF INTEGRALLY STIFFENED AND CONVENTIONAL STRUCTURE

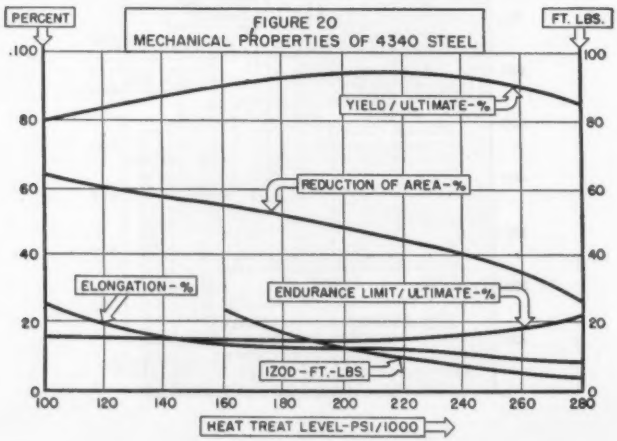


FIGURE 20
MECHANICAL PROPERTIES OF 4340 STEEL

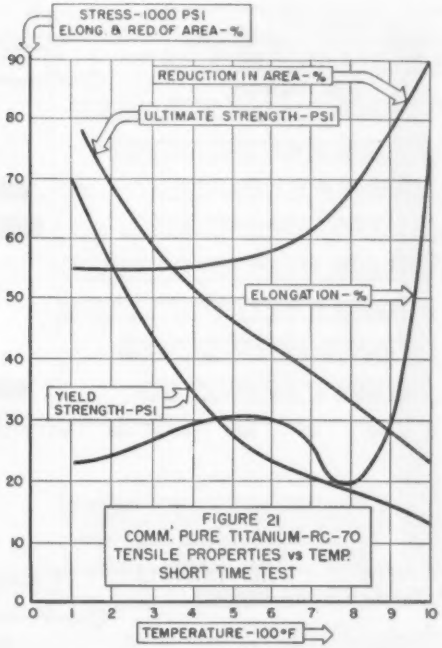


FIGURE 21
COMM. PURE TITANIUM-RC-70
TENSILE PROPERTIES vs TEMP.
SHORT TIME TEST

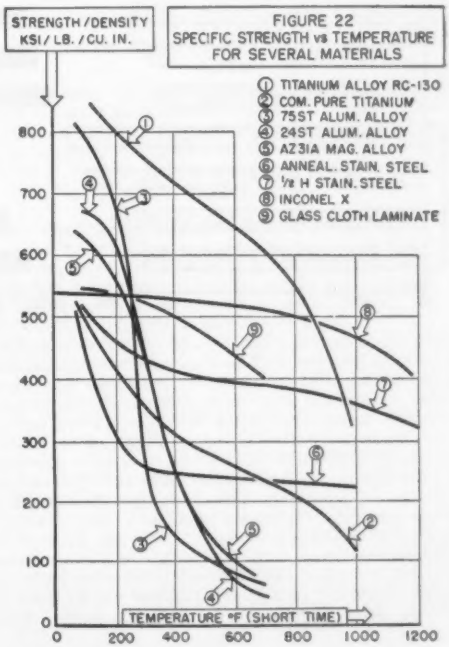


FIGURE 22
SPECIFIC STRENGTH vs TEMPERATURE
FOR SEVERAL MATERIALS

FIGURE 23
TENSILE PROPERTIES OF TI-MN-CR ALLOY
HEAT TREATED & AGED AS SHOWN

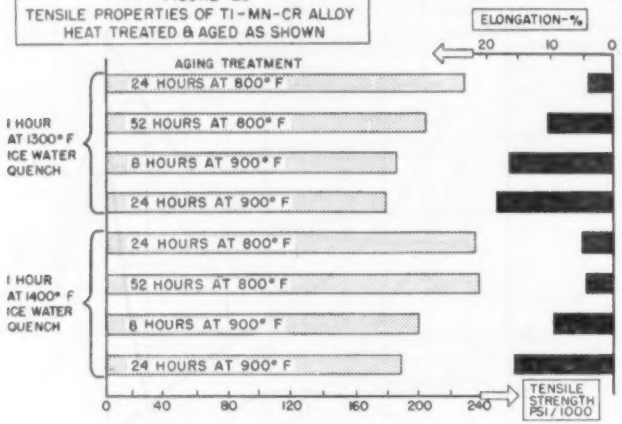
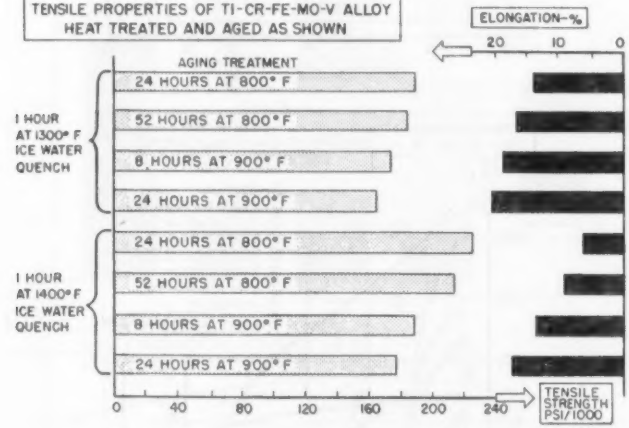
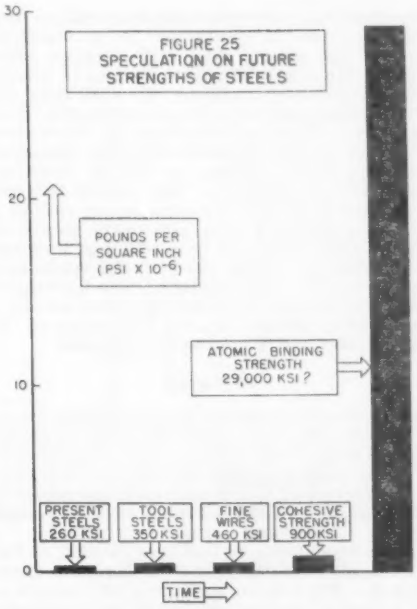


FIGURE 24
TENSILE PROPERTIES OF TI-CR-FE-MO-V ALLOY
HEAT TREATED AND AGED AS SHOWN





Planning and Development Stages of a Program To Investigate Hot Extrusion of Aircraft Structural Components

By Howard Benjamin, group supervisor, production methods group, production engineering department, Lockheed Aircraft Corp., California division, Burbank, Calif.

This paper summarizes the initial planning and selection of applicable shapes for hot extrusion of steel and titanium alloys. It presents the historical background of hot extruding progress and shows examples of economic advantages accruing through application of this prime fabrication method to aircraft components.

BACKGROUND

Steel extruding has been of some interest to industry for over 60 years. Patents covering the extrusion of steel were granted in the United States as early as 1893. Many patents have been issued during the intervening years and some actual extrusion has been done. Notable is the work done in Germany as early as 1935. Steel tube blooms were extruded on heavy vertical, mechanical presses and subsequently rolled and drawn into final shape.

The great difficulty inherent in extruding hot steel through steel dies caused a lapse of interest, and development of this art into a practical method of primary fabrication was sporadic. It was not until the French organization, Industrial Committee for Extrusion of Metals (Comptoir Industriel d'Etriage et Metaux) attracted attention by the announcement of the Ugine-Sejournet glass lubricant process that any great interest was aroused in the airframe industry. Until this time there is little evidence that structural shapes had been attempted, as most of the interest was centered around the production of tubing and tube blooms. The French process not only promised the possibility of obtaining shapes, but also made use of horizontal hydraulic presses similar to those already in use in this country for the extrusion of nonferrous alloys. From the time of the announcement of the Ugine-Sejournet processes in 1944 until the present there has been steel extrusion development work carried out in this country, but here again most of the interest was directed toward the production of tubes or tubular parts. With the advent of subsonic and supersonic type aircraft

and with both space conditions and operating temperature limitations becoming more and more critical, it was necessary that the airframe manufacturer give additional attention to the use of steel and titanium alloys for structural components of aircraft. In nearly all cases the use of complex cross-sectional shapes became desirable; however, as is the case with most aircraft production, usage involved tonnage quantities lower than is ordinarily encountered in normal steel fabrication processes. It became necessary for the airframe manufacturer to consider every possible method of producing these shapes and a full investigation was made of progressive forging, hot rolling, drawing, continuous machining, and combinations of the above. The results left much to be desired. For high production fabrication methods such as hot rolling, drawing, etc., the initial tooling cost and production setup costs were so great as to make such methods impractical. In methods such as machining, progressive forging, etc., the actual operational cost as well as the material waste involved made these methods far from economical. The results of this investigation, coupled with the optimistic reports concerning the French extrusion process, caused Lockheed to start a program of investigation into the limitations of this process and to determine the shapes which could be produced for our use.

PLANNING

During this same time another program, Extruded Blade Development Program, AMC Contract AF 33(038)-9355, was initiated by the USAF Industrial Planning Division and Curtiss-Wright Corporation. This program covered the development of materials, tools, methods, and techniques for extrusion of tapered steel tubes suitable for manufacture of hollow steel propeller blades, and indicated that there were unlimited possibilities for extrusion of other complex shapes in steel or other materials.

A first proposal outline was made by Lockheed to AMC in July 1949 in which a request was made to supply data obtained from Germany (Schloemann, Mannesman, etc.) and any other late and authoritative information on the steel extrusion process. This request ultimately resulted in the issuance by the USAF AMC of contract AF 33(038)-23981, steel extrusion experiments on airframe components. This Contract became effective May 29, 1951.

SELECTION OF APPLICATIONS

A survey of representative production Air Force strategic airplanes, as required by Phase I of the subject contract, was made to locate and evaluate specific production parts which could be produced as extrusions. An attempt was made to select parts which were sufficiently long or which had multiple usage so that the potential demand for the extrusions was great enough to result in production quantities. Consideration was also given to the saving in material as compared to the current production method of manufacture and to the possible reduction in fabrication time.

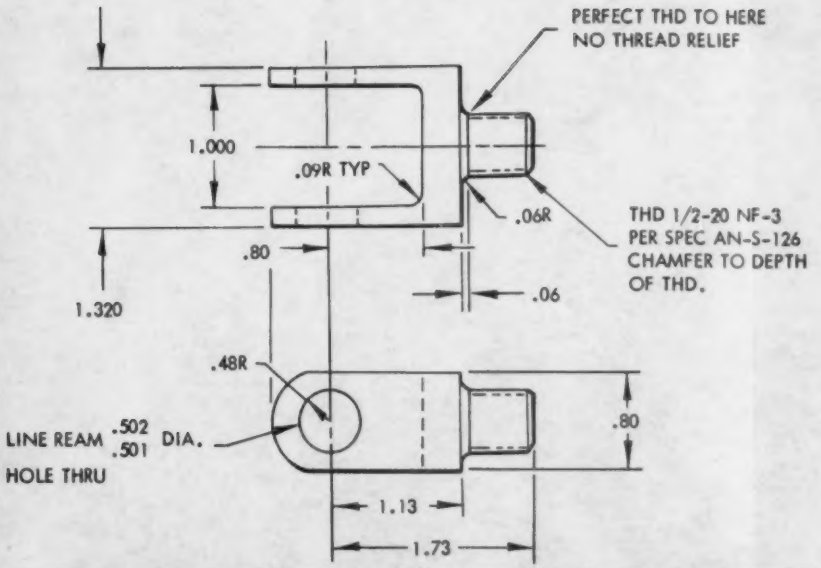
Airplanes investigated in the search for extrusion applications were: Boeing B-47 Bomber, North American F-86 Sabre fighter, Northrop F-89 Scorpion fighter, Lockheed F-94 all-weather interceptor.

Contacts were made at Consolidated-Vultee Aircraft Corporation, Chance-Vought Aircraft Corporation, Glenn L. Martin Company, and McDonnell Aircraft Corporation and, as a result, several drawings were submitted for incorporation in the survey.

All parts were segregated according to the general configuration of the cross section. Several distinct families of shapes became apparent as the tabulation of parts progressed, a summary of these being given herewith:

Basic shape:	*Number of parts in family*
H Section	4
Channel section	8
T Section	4
Angle Section	2

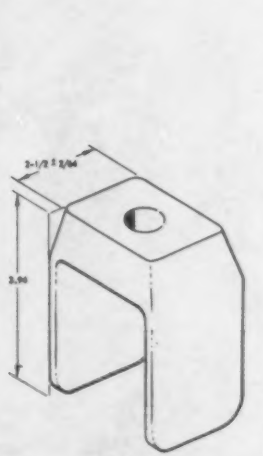
The parts selected for inclusion covered a wide range of design and included those fabricated from sheet stock, those machined from bar or plate, and those starting from forgings. A wide variation in size of cross section existed in the parts selected, ranging from areas of 0.016 square inches for the smallest part to 35.15 square inches for the largest part.



MATERIAL-4130 STL.-HT 180000-200000 PSI.			
BAR STOCK		EXTRUSION	
MATL	.40	MATL	.37
MACHINING	1.35	MACHINING	.68
TOTAL	$1.75	TOTAL	$1.05

FITTING-CLEVIS

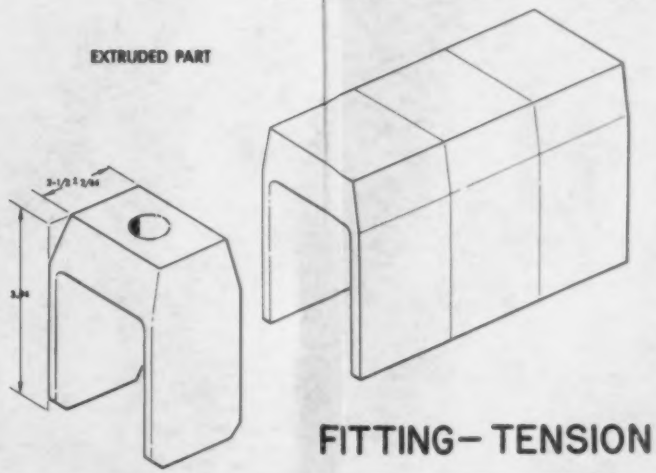
GROUP II PART: Although considerable machining is required the savings in material and roughing cuts results in overall finished part savings.



PRODUCTION PART
(FORGING)

SUMMARY				
	RAW STK. WT. LBS.	MAT. RMVD. IN%	FIN. WT. LBS.	COMPARATIVE COST
PROD. PART	2.06	16	1.73	$ 6.09
EXTRUDED PART	2.06	16	1.73	3.19

EXTRUDED PART

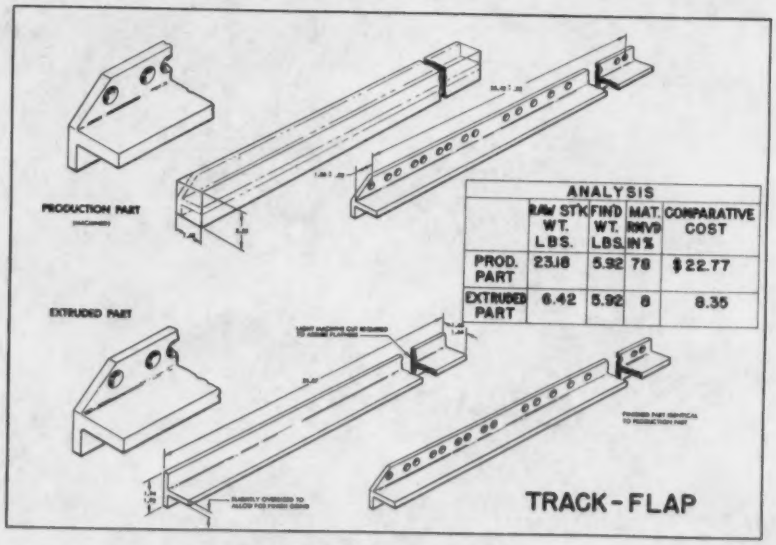


FITTING-TENSION

GROUP I PART: A minimum amount of machining is required to produce this part from a steel extruded shape.

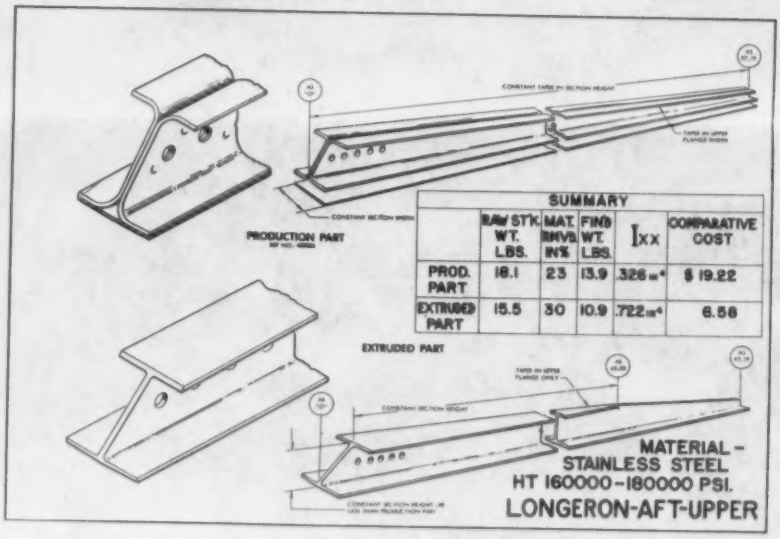
Figure 1

Figure 3



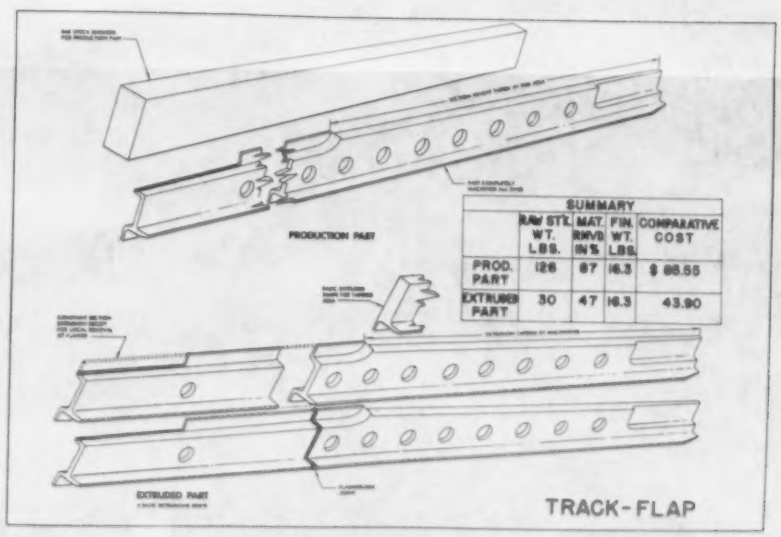
ANALYSIS

	R/w STK WT. LBS.	FIN'D WT. LBS.	MAT. RMVD IN %	COMPARATIVE COST
PROD. PART	23.18	5.92	78	$ 22.77
EXTRUDED PART	6.42	5.92	8	8.35



SUMMARY

	R/w STK. WT. LBS.	MAT. RMVD IN %	FIN'D WT. LBS.	Ixx	COMPARATIVE COST
PROD. PART	18.1	23	13.9	.326 in⁴	$ 19.22
EXTRUDED PART	15.5	30	10.9	.722 in⁴	6.58



SUMMARY

	R/w STL. WT. LBS.	MAT. RMVD IN %	FIN. WT. LBS.	COMPARATIVE COST
PROD. PART	126	87	16.3	$ 88.55
EXTRUDED PART	30	47	16.3	43.90

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Summary of maximum and minimum dimensions

	Inches
Minimum thickness of section	0.032
Maximum thickness of section	4.00
Maximum overall dimension of section	12.25
Maximum length of part	97.00

An analysis of each part indicated two approaches to the development of an extrusion having equivalent structural properties. The simplest and most direct approach is to extrude a section to the exact dimensions and cross-sectional shape of the finished part. Some parts cannot be handled this way, due to anticipated limitations of the extrusion process or due to the design of the part itself, in which case the extrusion must have various deviations from the final part cross section and then be altered by a subsequent operation such as machining or cold-drawing.

Accordingly, the final tabulation and summary of applicable production parts was set up on this basis. Group I included parts extruded to final shape, and Group II included parts which could only be extruded to a modified shape and then followed by other operations to produce tapers, changes in section, and similar irregularities (fig. 1). A third group was added to include parts applicable to future designs after the completion of further development work.

EXPERIMENTAL DEVELOPMENT OF SPECIFIC SHAPES

From the compilation of shapes from Phase I three parts were selected for experimental development (fig. 2). These were selected so that the extrusion of each part became more difficult from one section to the next (fig. 3).

The necessary dies were built to produce each of the three parts and development work was conducted using 8630, 4340 stainless steel, and three selected titanium alloys. In conjunction with this work additional investigation was made on the effect or limitation of the following items:

1. Complexity of cross-sectional shape.
2. Minimum thickness limitations.
3. Effect of adjacent thick and thin sections.
4. Effect of extrusion die entrance angle and length of bearing surface on flow conditions of the material.

Enough parts were extruded to supply material for physical properties including ultimate tensile, tensile yield, and elongation in both longitudinal and transverse directions, compressive yield, notch fatigue, and microstructure analysis. Fatigue properties were evaluated for steel extrusions at high heat treats; 8360 at 180 KSI and 4390 at 280 KSI.

At the offset of the program, it was recognized that several basic items would have to be established before any successful extrusion could be expected. Consequently, the test program included the following:

1. Evaluation of lubricants.
2. Determination of optimum extruding temperature.
3. Determination of physical properties as a function of extrusion ratio.
4. Determination of limitations on slenderness ratio.

The first three items were adjudged on the basis of rounds, with extrusion ratios ranging from 10 to 100. The fourth item involved a special shape designed to allow varying relationship of thick to thin adjacent areas.

Hot Extrusion of Alloy Steel and Titanium Shapes

(By G. A. Moudry, Harvey Machine Co., Inc., Torrance, Calif.)

A presentation prepared for the Production and Resources Division, United States Air Force Air Materiel Command, Wright-Patterson Air Force Base. It summarizes the investigational work completed by The Harvey Machine Co., Inc., toward the end of establishing production procedures and determining metallurgical characteristics of extruded titanium and steel alloy shapes

It is a distinct honor to be before this gathering today—not only because of the high calibre of the audience, but because the very fact of your presence attests to the interest in the subject and the success of the project under discussion.

As an aluminum man, it seems almost heretical to discuss the competitor metals, titanium and steel. However, we at Harvey realize the limitation of

present known aluminum alloys in aircraft construction when faced with the thermal barrier encountered by supersonic aircraft of today.

Aluminum alloys as yet are the best structural material for the aircraft engineer on a strength-weight ratio at temperatures up to approximately 250° F. Our problem has been to develop an aluminum alloy which will perform satisfactorily at temperatures from 200° to 700° F. This we have not as yet accomplished and, in fact, we have nothing on the horizon to turn to.

The inadequacy of aluminum and magnesium base alloys at higher speeds and higher temperatures has been recognized for some time. Alloy steel has been with us for years and, although three times the weight of aluminum, it has been accepted as a necessity in many components of the plane of today. Titanium, the newcomer in the structural metal field, has been with us but for a short time. However, it is already accepted and although we are scarcely at the fringe of its ultimate development, it is established as a necessary and vital material for aircraft use as speeds increase and design space runs out.

Steel and titanium alloy sheet, rod and bar, and some forgings are available for procurement and use. Extruded shapes, however, were nonexistent. Because, since the advent of the aluminum plane, aluminum alloy extruded shapes have been the backbone of today's aircraft, it was necessary that efforts be made to establish methods for the procurement of these structural components in steel and titanium alloys.

It hardly seems necessary, but it should be stated clearly at this time that the Air Force Air Materiel Command should receive complete credit for the instigation of the extrusion program of titanium and steel alloys discussed here today. The first satisfactory steel and titanium alloy extrusions for aircraft were produced on this program sponsored by the Production and Resources Division of Wright-Patterson Field. The Air Force, through AMC, has kept step with titanium alloy development and has instigated most of the programs which have resulted in successful application of titanium alloys for vital aircraft sections.

The extrusion of metals as a fabricating process is not new, nor is it novel, but it is effective. There is no other known process that works metal more effectively in one operation than that of extrusion. In one operation a cast billet of, let us say, 10″ in length can be changed into a wrought shape with complex cross-section up to lengths of one hundred feet. Aluminum extrusions have been produced in this country for over thirty years. You all have seen the variety of shapes that can be produced and how this metalworking method has assisted in revolutionizing structural design.

The hot extrusion of steel and titanium, however, is novel although discussions of the subject are not new. The adjective "hot" is used to differentiate from the much-publicized "cold" or "impact type" of pressing or extrusion. The temperatures used in this discussion are in the neighborhood of 2300° F. for steel and 1800° F. for titanium.

Shapes are classified as having cross-sectional configurations other than rounds, squares, and rectangles.

The process of extrusion has often been described as a simile to the toothpaste tube, wherein pressure on the tube results in the toothpaste emerging as a configuration identical to the configuration of the tube orifice. This is indeed an extreme oversimplification. The work we are reporting on today is far from the toothpaste category.

Briefly, the purpose of this investigation was to produce steel and titanium alloy extruded shapes with good surface, close tolerances, proper metallurgical characteristics, and suitability for use in aircraft structural components.

If hot steel and titanium extrusion could be developed into an economically sound and technologically feasible process, a fabrication method of particular interest to the aircraft industry would be at hand. The extrusion process permits fabrication of shapes too complex to be rolled; permits production of relatively small lots of special shapes due to relatively moderate cost of extrusion dies; and permits fabrication of alloys which cannot be successfully rolled. Complicated steel and titanium shapes currently used in aircraft to a limited extent are produced by machining from bar stock. The potential saving of time and labor if such shapes can be produced by extrusion is enormous. Furthermore, machining of such shapes from bar stock reduces most of the metal to chips. The necessity for conserving metals during critical periods hardly needs emphasizing to be appreciated.

Lockheed Aircraft must be given due credit at this time for visualizing the need for steel extrusions and taking steps to further development.

Steel is one of the easiest metals to work—except for the temperature. In its plastic range its flow characteristics in comparison to aluminum are excellent. The difficulty is in the fact that alloy steel is being contained and extruded in steel tools and dies. With temperatures up to 2300° F. and pressures over 100,000 PSI, few materials are within reach of the metallurgist to withstand this operation.

Lubrication must be provided as an interface between the flowing steel and the surface of the die. This is used as a protection to prevent the die bearing from extruding along with the billet. For the extrusion of aluminum, lubrication is to be abhorred rather than desired.

Another requisite is to get the hot steel billet out of the container and through the die as rapidly as possible. Any pause will result in overheating of tools and subsequent tool failure. Aluminum extrusion cycles vary from one minute to as long as thirty minutes. Steel is extruded in a matter of seconds. This illustrates the excellent flow characteristics of the metal.

A great amount of industrial experience and production know-how has been accumulated in the aluminum extrusion industry. The information and experience available at Harvey was applied to the problem of hot extruding steel shapes. The extrusion know-how thus applied includes effective use of presses and furnaces, as well as effective utilization of facilities for tooling design and fabrication.

The work covered in this discussion was conducted on a 1650-ton hydraulic horizontal extrusion press designed for aluminum alloy shape production. For our steel work, billets 6 5/16" in diameter were used and for titanium, to reduce costs, a diameter of 5" was employed.

Extrusion pressures proved to be moderate and definitely below those used for aluminum alloys. Hydraulic pressures averaged 3,000 PSI and down to 2,000 PSI, with 4,200 PSI available. This is one of the paradoxes of metalworking in that aluminum alloys, considered soft, require greater force to work in their plastic range than does titanium or steel.

The furnace used for heating of billets was an electrically heated salt bath using salt of barium chloride, sodium chloride mixture.

A specific objective in the round bar extrusion program was a test of steel extrusion lubricants. The scope of the program precluded exhaustive tests of the many lubricants which might be conceived; work was limited to exploratory tests on five lubricating materials.

In the hot extrusion of steel, the lubrication problem assumes greater significance than is the case with nonferrous extrusion practice. When extruding steel, the lubricant is expected to insulate and protect tooling surfaces from high billet temperatures; as well as to reduce friction and thereby lower extruding pressures.

It appears possible to attain suitably low extrusion pressures and acceptable extruded surface condition with any of a variety of lubricants; particularly when, as in our practice, molten salt from the heating furnace is left on the billet to be extruded. However, it is much more difficult to accomplish suitable die protection at the same time. It is the latter requirement that makes satisfactory solution of the lubrication problem in connection with steel extrusion elusive.

Conventional lubrication practice for metal fabrication generally involves use of carbonaceous lubricants such as graphite and petroleum base products.

Special purpose lubricants, such as soap base lubricants, phosphates, metallic coatings, molten salts, etc., are also used in metal fabrication. A fairly recent innovation is the use of molydisulfide as an additive to lubricants or as a lubricant.

A different type of lubrication, a type which may be considered peculiar to hot fabrication, is the use of solid refractory lubricating materials. Materials of this type soften at the working temperature range of the material being formed. That portion of the lubricant next to relatively cool die or tooling surface remains solid and thereby prevents direct contact between tool surface and hot workpiece. The portion of the lubricant adjacent to the workpiece becomes liquid and flows with the metal being formed.

Five lubricants were tested in the subject investigation and these fall into three categories.

Category A: Carbonaceous lubrication with molydisulfide added, or without such additives. Various proprietary lubes fall into this category.

Category B: Refractory solid lubricants. In this category the following materials were tested: glass wool, muscovite (white mica), anorthite (lime feldspar).

Category C: Molten salt from salt bath furnace.

Another specific objective of the program was to investigate the effect of extrusion temperature. Using stainless type 410 steel it was determined that extrudability was best for this alloy at the highest temperature in the range of 2150°F. At lower temperatures extrusion time and pressure increased considerably to cause stoppage of extrusion. For titanium alloys, an extrusion temperature of 1800°F. appeared optimum, although some work was conducted at as low as 1700°F.

Third objective in the round bar extrusion program was to investigate the effect of extrusion ratio. Tests were conducted to determine the effect of extrusion ratio on mechanical properties of extruded bars, extrusion pressure, extrusion time.

For steel, three alloys (SAE 8630, SAE 4340, and Stainless Type 410) were extruded in six different extrusion ratios. Extrusion ratio as used here means cross-sectional area of billet divided by cross-sectional area of extruded bar.

The extrusion ratios used varied from ratio 5 to ratio 100; bar diameters from 2.770" to 0.630".

Mechanical properties of extruded bars were determined for the as extruded condition, also for heat treated extrusions and for annealed extrusions.

For titanium, the three alloys investigated were extruded in four different extrusion ratios—from 10 to 100, and bar diameters of 0.500" to 1.58".

In the extruding of aluminum alloys, it is common practice to manually guide the forward end of relatively thin extrusions as they progress along the run-out table. This is necessary to preclude the possibility of a long extrusion buckling or bending. The relatively slow run-out speeds used in the aluminum extrusion process, of from two feet per minute up to one hundred feet per minute, permit the guidance of the forward end of the extrusion. Heavier sections are given corrective guiding at the start of the extrusion. In either case it is relatively easy to maintain straightness in the extruded aluminum alloy piece.

In the case of steel extrusion, run-out speeds are on the order of five hundred to fifteen hundred feet per minute. At these run-out speeds manual guiding of extruded pieces is not possible. In most steel extrusions reported prior to the present work, guiding was not a serious problem because steel extrusions were either heavy enough to need no guiding except the run-out table itself; or in other cases, extrusions were short enough that fairly simple mechanical guides were contrived. I give you an example of our first difficulties.

In the case of steel extrusions, straightening after heat treat again involves somewhat more complex problems than does straightening of heat treatable aluminum alloys. Long aluminum alloy extrusions become badly distorter during the solution heat treatment operation and are stretch-straightened immediately following quenching from an elevated temperature. In this condition the aluminum alloy is still soft and easily stretched. It hardens after stretching by natural aging in the case of some alloys, or is hardened by artificial aging (precipitation heat treatment) in the case of others. However, in the case of steel, no such soft transition stage exists, since quenching of steel produces an immediately hard material (martensite) which must then be tempered to restore useful ductility and softness.

After heat treatment, considerable bow was present in almost all the steel extursions and the average was approximately one foot of lateral deviation in twelve foot length. It was found possible to remove all perceptible bow and twist by stretching and detwisting (1½ to 2 percent stretch) at the hardness level of this heat treatment (which was approximately 180,000 p. s. i.).

It was necessary to cut extursions into twelve foot lengths for heat treating, since this was the greatest length accommodated by the only vertical steel heat treating furnace in the area. It was considered essential to heat treat and quench which extrusions held in vertical aspect in order to keep distortion at a minimum.

Side shows typical heat treated twelve foot extrusions prior to straightening.

Slide shows two heat treated and straightened extrusions.

Each method of working a metal results in a product which possesses metallurgical characteristics inherent to that particular method. To determine the ability of a part produced by any new method to meet the standards established for existing methods one must examine closely the effects of those inherent

characteristics of the new method. This is essentially what we have attempted to do in exaluating steel extrusion products.

Two important characteristics of the extrusions process can be considered. First, the degree of metalworking increases progressively from front to rear, and decreases progressively from surface to center of the extrusion. The variation in degree of hot work will result in a variation of grain size and grain coarsening temperatures. The greater the effective reduction, the finer is the grain size. The following photomicrographs illustrate this point. The three photomicrographs represent 10:1, 20:1, and 100:1 extrusion ratios, respectively. The material is 8630 extruded and annealed. The grain sizes are ASTM 6, 7, and 8 respectively.

Contrary to this effect, is the effect of the degree of hot work on coarsening temperatures. The greater the degree of hot work, the lower the grain coarsening temperature. However, the range of hot work encountered does not lower the coarsening temperature to a degree which might result in appreciable coarsening during annealing, normalizing, or hardening.

The second important characteristic of the extrusion process is the relatively hydrostatic stress state which exists. This results in high density metal, with good continuity of flow lines, and very little tendency for sponginess. In terms of mechanical properties, this means good elongation, high reduction of area, and good notch impact strength in transverse directions.

The characteristic extrusion effect resulting in enhanced tensile and yield strengths in the extrusion direction would not be expected, and was not observed in the extruded steel sections. This is logical since such an extrusion effect is a result of preferred orientation, and any preferred orientation of the austenite would be lost as the steel extrusion cools through the transformation temperature. Consequently, the ultimate and yield strengths would be nearly independent of specimen orientation.

With these considerations in mind, we could conclude that the quality of extruded sections would be approximately equivalent or superior to rolled sections. The possible differences might be slightly better transverse ductility and toughness in the extruded section, but slightly more grain size variation.

Examining the microstructures and properties of steel extrusions will give further indication of the normality of extruded steel.

The following three photomicrographs will show them as extruded structure of 8630, 4340, and type 410 Stainless, extrusion ratio 50:1.

The 8630 microstructure shows a definite Widmanstatten structure in which the light etching ferrite has formed along certain crystallographic planes as well as at grain boundaries. This is a result of an air cool from a very high austenitic temperature. The high temperature increases the hardenability of the medium hardenable 8630 and subsequent air cooling results in pro-eutectoid ferrite forming at a lower temperature. This lower temperature ferrite is nucleated along definite crystallographic planes.

The 4340 structure shows the typical mixed pro-eutectoid ferrite, upper and lower bainite, and untempered martensite of a fairly deep hardening steel when air cooled in a small section.

The type 410 Stainless structure is nearly completely a low carbon untempered martensite. This is consistent with the air hardening characteristics of 410 Stainless.

This graph shows the mechanical properties of "as extruded" 410 Stainless after extrusion at 2000° F. and 2150° F. The ultimate and yield tensile strengths decrease with extrusion temperature. This apparent anomaly is readily explainable by referring to the 12% Cr section of the three-dimensional ternary Fe-Cr-C equilibrium diagram. At 1950° F. the structure is completely austenitic. At 2000° F. and 2150° F. progressively more ferrite is stable. This is the result of the effect of Cr on narrowing the stability range of austenite. Upon cooling, this ferrite is not available for martensitic hardening and remains as patches of ferrite in a martensitic matrix. Reheating within the austenite field will entirely eliminate this effect.

The following graphs will show the effect of extrusion ratio on the as extruded properties of 8630 and 410 respectively.

The 8630 shows a negligible effcet. The hardenability of this steel is so low that even the 0.680" round resulting from the 100:1 extrusion ratio did not air harden appreciably.

The tensile strength of 190,000 PSI in the 2.77" section corresponding to a 5:1 extrusion ratio and a gradual increase in smaller sections is indicative of the high hardenability of type 410 Stainless when cooled from 2150° F.

The heat treated properties of these alloys were not noticeably effected by the extrusion ratio. Detailed study of properties produced an indication of product quality. Digressing for a moment to the fundamental data obtainable from a tensile test, we remember that the elongation of a tensile specimen over a two inch gage length reflects primary the strain hardening characteristics. However, the reduction of area derived from the necking of the specimen is strongly structure sensitive. Consequently, a low reduction of area value is a good indication of the presence of minor variables not under control.

The following graph shows the normal expected reduction of area range for fully martensitic steels (0.25–0.45 percent C) tempered to various strength levels. The plotted points represent the elongations and reduction of areas of the extruded and heat treated 8630, 4340 and 410 Stainless. The 410 Stainless does not belong to the class of steels represented by the expectancy curves but was included for comparative purposes.

It is interesting to note that the values specified in MIL–H–6875 (Heat Treatment of Aircraft Steels) practically coincide with the —10 percent curve.

The high reduction of area values obtained are indicative of sound material, relatively free of porosity and detrimental inclusions, and probably possessing good impact properties.

The next graph plots the "as extruded" reduction of areas relative to the normal expectancy curve for quenched and tempered structures. It is obvious that the material should not be placed in service in the as extruded condition.

These low values of "reduction of area" and "elongation" can easily be accounted for by referring to the "as extruded" microstructures. In the 8630 material we have a mixed structure of grain boundary ferrite, Widmanstatten ferrite, and Fe_3C with a large prior austenite grain size.

In the 4340 material we have a mixed structure of untempered martensite, blocky ferrite, and bainite, again with a large prior austenitic grain size.

In the 410 Stainless we had principally untempered martensite.

Full heat treatment was required to obtain a satisfactory structure in the 8630 and 4340 extrusions. However, in smaller section 410 Stainless where the "as extruded" structure was nearly completely untempered martensite, a normal draw gives excellent properties.

The next photo shows some shapes with various slenderness ratios—and the following graph shows the effect of section thickness on as extruded properties of 4340 and 410 Stainless. This shows the air hardening tendency of these steels.

The next picture shows some structural shapes—and the following graph shows the effect of section thickness on "as extruded" properties of 8630, 4340, and 431. The 8630 shows no tendency for air hardening, the 4340 air hardens strongly in sections below 0.3" and the 431 air hardens at all thicknesses considered.

Three titanium alloys were extruded in this project. They were—

Titanium Metals Ti 150–A, with a nominal 1.5 Fe—2.5 Cr.

Rem-Cru RC 130–B, with a nominal 5.0 A1—5.0 Mn.

Mallory Sharon MST 3 A1—5 Cr.

The upper critical for these alloys is approximately 1700° to 1800° F. Extrusion temperatures covered the range from 1700° F. to 1875° F. Consequently, the hot work took place either very high in the Alpha + Betal field or completely within the Beta field. Subsequent cooling resulted in nucleation and growth of the pro-eutectoid Alpha.

Slide #TM–56 shows the microstructure of the forged billet of the Mallory Sharon alloy at 100X magnification.

Slide #TM–42–100X and TM–42–500X show the microstructure of this material after extruding at 1800° F. (extrusion ratio 20). The magnifications were 100X and 500X respectively.

Slide #TM–58 shows the microstructure of the forged billet of Ti 150–A. Slides #TM–38–100 and TM–38–500 show the microstructure of Ti 150–A extruded at 1800° F. (extrusion ratio 20). The magnifications are 100X and 500X respectively.

Slide #TM–57 shows the microstructure of the forged billet of Rem-Cru 130–B. Slides #TM–29L–100X and TM–29L–500X show the microstructure of Rem-Cru 130–B extruded at 1800° F. (extrusion ratio 10). The magnifications are 100X and 500X respectively.

The forged billets were apparently forged fairly low in the Alpha+Beta temperature range. The resultant structure contains a very high percentage of pro-eutectoid Alpha.

The "as extruded" microstructures shown were taken in a direction transverse to the direction of extrusion. A fairly continuous network of Alpha outlines the grains. It should be noted that the grains are equiaxed. This indicates that the transformation took place during the cooling cycle subsequent to the extrusion through the die. The carbides in the Mallory Sharon alloy were not in solution at the billet preheat temperature. Consequently, they reveal the extrusion flow pattern.

The extrusion temperature over the range investigated (1700° to 1875° F.) had very little effect on the microstructures of these three alloys.

The effect of the extrusion temperature on the mechanical properties of Ti 150–A are shown in Slide #TC–1.

The extrusion ratio had varying effects on the microstructures of the three alloys. The distribution and nature of the precipitated Alpha depends essentially on the temperature at which the Alpha was formed. The as extruded structures then were dependent on the cooling rate of the extrusion. This cooling rate was directly dependent on the extrusion ratio and resulting section size. Slow cooling rates occurring with low extrusion ratios resulted in relatively coarse Alpha precipitation within the grain and as a grain boundary network. Faster cooling rates result in a less continuous and finer network of Alpha at the grain boundaries and a much finer Alpha within the grain. This cooling rate effect was most pronounced on the Mallory Sharon alloy, and least pronounced on the Rem-Cru alloy. These microstructural variations correlate directly with the mechanical properties.

Slide #TC–2 plots the effect of extrusion ratio on the mechanical properties of Mallory Sharon 3 Al 5 Cr.

Slide #TC–3 plots the effect of extrusion ratio on the mechanical properties of Ti 150–A.

Slide #TC–4 plots the effect of extrusion ratio on the mechanical properties of Rem-Cru 130–B.

In general, the following metallurgical conclusions can be stated at this time for titanium:

1. Extrusion temperatures from 1700° to 1875° F. appear to have very little effect on the resulting properties.

2. "As extruded" properties were in general similar to published typicals for hot rolled bar and forgings.

3. Extruded sections show an unworked proeutectoid Alpha outlining the grains.

4. The distribution of Alpha depends on the cooling rate of the extrusion, and hence is dependent on section size. Large sections contain more coarse Widmanstatten Alpha nucleated within the grain, whereas thin sections contain more fine Alpha nucleated preferentially at the grain boundary.

The extrusion of titanium alloys is particularly attractive to the structural engineer in that the very nature of the extrusion process tends to give a uniform product through a blending working in the container of the extrusion press. Through this mixing operation, the problem of segregation that has given some trouble in rolled material is considerably minimized. The mechanical properties of extruded lengths have been very uniform from front to rear.

Today's titanium alloys with ultimate strengths up to 150,000 PSI will go far toward bridging the gap between present structural materials and desired mechanical properties in airframe structure. The alloy development work successfully conducted by the Air Force WADC in conjunction with Battelle, certainly is sufficiently encouraging to warrant an optimistic outlook for the future of titanium alloy usage.

I have here an illustration of a common component of one of the production planes of today. It is a longeron, four of which are used in the tail section of a jet plane. Because of heat, aluminum alloys cannot be used except at a great sacrifice of weight to supply necessary strength at temperature. Today stainless steel sheet is welded and riveted together with doublers to provide the structural part. With the use of a stainless steel extrusion the part can be produced at one-third the cost of the built-up part, and at weight saving of three pounds out of 13.9 pounds. With availability of titanium the same part could be extruded as one piece at a further weight saving of almost five pounds per section. This section is an extruded titanium alloy with a tensile strength of 150,000 pounds per square inch. It is as extruded with no subsequent operations except straightening, sandblasting and a machining cut to produce the taper. The finish is satisfactory as is. It is one example of countless numbers

of sections which will be used in airframe design and structural components when titanium metal is available.

In summary, we can state the following:

Alloy steel and titanium can be, and has been, extruded successfully into shapes of substantial lengths. Good surface and tolerances have been obtained.

With proper finishing equipment and techniques, straightness tolerances such as bow and twist can be maintained similar to that of aluminum.

The metallurgical and mechanical properties of extruded and heat treated steel alloys are entirely satisfactory. No problems from this method of working have been encountered, or are expected.

No extrusion effect as normally defined for aluminum alloys is encountered.

Steel extrusions respond to heat treatment in a manner similar to steel worked by other methods.

Property variations are practically nonexistent over the length of the section from front to rear, and edge to center, in heat treated sections.

There is a definite economic advantage in the use of extruded shapes over parts machined from bar and rod. How great this advantage can be is dependent on the configuration of the section and the cost of machining over the cost of extrusion.

It has not been my intention to underestimate the difficulties in the hot extrusion of alloy steel and titanium shapes—nor do I desire to leave you with a sense of security that the procurement problem has been entirely eliminated. The work that we are reporting on today is a result of a development and research program. We are not guaranteeing unlimited production of extruded shapes to perfect tolerances and at negligible costs. However, I do state that what has been accomplished, has been repeated, and undoubtedly will be improved upon in the future. This has been no accident. We are at the threshold of a new fabricating method for steel and titanium—The Hot Extrusion of Alloy Steel and Titanium Shapes.

NOTES FOR MEETING—SENATOR MALONE'S SUBCOMMITTEE ON TITANIUM, NOVEMBER 23, 1953, WASHINGTON, D. C.

I. INTRODUCTION

Rem-Cru Titanium, Inc., jointly owned by Remington Arms Company, Inc. (a Du Pont subsidiary) and the Crucible Steel Company of America, produces wrought titanium mill products. Its headquarters, including sales, research, melt shop, and general administrative offices, are located in Midland, Pennsylvania, not far from Pittsburgh. Rem-Cru does not produce metallic titanium sponge but purchases it principally from E. I. du Pont de Nemours and Company.

Rem-Cru operates its own melting department, utilizing furnaces of its own design to produce ingots of titanium and titanium-base alloys weighing up to two tons each. Processing of these ingots is done on Crucible's specialty steel-mill facilities supplemented by others wherever required. Rem-Cru is supplying billets, bars, simple forgings, plate, tubing, wire, strip, and sheet in both commercially pure and alloyed titanium.

Rem-Cru was formed by Remington Arms Company, Inc., and the Crucible Steel Company of America in August of 1950. The two companies united their "know-how" and manufacturing techniques, resulting from previous research and development work. Remington's investigations on titanium were initiated in early 1947, and this company was the first to announce its commercial interest in titanium and to make samples available for outside evaluation. Research and development have continued in Rem-Cru at a relatively high rate—$3,500,000 have been spent to date. Approximately 30% of Rem-Cru's present employees are technical and engineering graduates assigned to the further development of titanium.

II. PRODUCTION

Rem-Cru's production during 1953 has been limited only by the availability of sponge. Performance against forecast and promises to its customers can be illustrated as follows:

Period	Promises and forecasts	Shipments	Percent performance
	Pounds	*Pounds*	
First quarter	195,000	153,952	78.9
Second quarter	241,400	266,445	110.4
Third quarter	297,000	260,570	87.7
October	100,000	115,897	115.9
Total	833,400	796,864	95.6

These shipments of good products represent average yields from sponge of 60–65 percent. A large percentage of the above product has been in the form of alloy sheet for such advanced planes as the F–100 and F–102 and in billet form for the J–73 jet engine.

Rem-Cru will produce and ship in 1953 between 500 and 600 tons of wrought titanium products. This is an increase over 1952 of fourfold. Melting production has reached a maximum of 125 tons in the month of October. This increase of over threefold in the past year was made possible by supplementing the Du Pont supply with sponge from the Government rotating fund stockpile, small shipments from Japan and the use of remelt scrap.

Rem-Cru considers the quality of its products of even greater importance than the quantities being produced. Quality control engineers applying statistical control methods have made it possible to improve all aspects of quality but, in particular, the uniformity of the material with respect to physical properties and mechanical condition.

Rem-Cru's facilities have been financed entirely by its two parent companies. No Government assistance has been obtained. Rem-Cru requires and has at its disposal for the rolling and fabricating of its products over $100,000,000 of plant investment of the Crucible Steel Co. Rem-Cru's research and development program on alloys and melting has also been supported by the company, except for that sponsored by the Government, corresponding to less than 10 percent of the total.

III. REM-CRU FIRSTS

In its segment of the titanium industry, namely the production of wrought products, Rem-Cru has pioneered the following items:

(*a*) It developed the first titanium alloy sheet and is currently shipping 10 to 20 tons per month.

(*b*) It produced the first 2-ton ingot and several of these are currently being produced each week.

(*c*) It produced the first wide titanium strip on continuous hot and cold strip mill facilities. Several such strips are now being produced each month.

(*d*) It developed the first all-alpha alloy which is weldable and which possesses improved high temperature properties. Production is just now being undertaken on this new alloy.

IV. SCRAP RECOVERY

Rem-Cru has recognized from the beginning that the supply of titanium metal could be extended and the cost of wrought products reduced through efficient utilization of scrap titanium metal from its own and its customers' operations. Accordingly, the scrap remelt problem has been attacked along several lines in order to permit the reuse of the maximum quantity of material at the earliest possible time. Methods have been developed for reducing trimmings, turnings and sheared ends to sufficiently small particle size so that it can be fed with the titanium sponge into our conventional melting furnaces. As a result, the use of such scrap has averaged approximately 10,000 pounds per month for the last 6 months, or 5–10 percent of the ingot tons produced. During this period, approximately 15,000 pounds of titanium turnings have been purchased from customers and scrap dealers and have been used. The company's net accumulation of potentially usable scrap is about 10 percent of its total purchases of sponge (150 tons of scrap).

Development work on additional means of utilizing scrap is continuing along the following lines:

(*a*) Means of consolidating massive scrap so that it can be used as consumable electrodes in conventional cold mold furnaces.

(*b*) Rem-Cru has under development a new type of melting procedure which will permit the direct utilization of all types of scrap. This new type of furnace will also permit the production of higher quality ingots.

V. FUTURE PRODUCTION

It is the policy of Rem-Cru to provide melting and fabricating capacity equal to or greater than its available sponge supply. Accordingly, additional melting facilities are now under construction which will raise our average melting capacity to 12 tons per day during the first half of 1954.

We are planning to expand beyond this rate as required. Studies are under way to determine the facilities needed to handle the metal which might be available under the present sponge production expansion program. It is likely that certain existing steel mill facilities must be supplemented in order to handle efficiently the tonnages of titanium to be produced during the next 5 years. Our studies will point up these requirements well in advance.

VI. CONCLUSIONS

Rem-Cru is very much aware of the importance of titanium to the defense effort and has made a major contribution to the establishment of the titanium industry. It is currently devoting its efforts to performing a sound, quality-conscious job and simultaneously planning for continuing healthy growth during the years ahead.

CONTRACT No. DMP–6

BETWEEN THE UNITED STATES OF AMERICA AND E. I. DU PONT DE NEMOURS AND COMPANY

This contract, made and entered into this 24th day of July, 1952, between the United States of America (hereinafter called the "Government"), acting by and through the Administrator of the Defense Materials Procurement Agency, and E. I. du Pont de Nemours and Company, a corporation organized and existing under the laws of the State of Delaware (hereinafter called the "Contractor").

WITNESSETH

Whereas titanium metal sponge is now manufactured by the Contractor in limited quantities from titanium tetrachloride and magnesium at Contractor's plant at Newport, Delaware, and titanium tetrachloride is manufactured by the Contractor from raw materials at Contractor's plant at Edge Moor, Delaware, for use in various activities, including titanium metal sponge manufacture; and

Whereas the expansion of titanium metal sponge productive capacity is not justified as a strictly commercial venture in view of the uncertainty of civilian markets and the possible early obsolescence of the Contractor's present manufacturing processes; and

Whereas to facilitate the national defense, the Government desires the Contractor to expand its currently existing productive capacity for the manufacture of titanium metal sponge from raw materials by an additional 2,700 short tons per annum.

Now, therefore, subject to the terms and conditions hereof, the parties hereto agree as follows:

ARTICLE I

ADDITIONAL PRODUCTION

During the term of this contract, the Contractor shall produce and dispose of, in accordance with the terms hereof, 13,500 short tons (2,000 pounds each) of titanium metal sponge (hereinafter referred to as "additional production") to be derived from the facilities (hereinafter referred to as "additional facilities") described in paragraph 1 of Article II of this contract which the Contractor will provide and operate for the purpose of producing such titanium metal sponge. The additional production shall be at an annual rate, up to the actual capacity of the additional facilities, sufficient to supply bona fide customers (including the Government) with titanium metal sponge at prices and on terms acceptable

to the Contractor; provided, however, that additional production shall not be required unless the Contractor has bona fide orders for titanium metal sponge which will justify full production from the Contractor's existing facilities (75 short tons per month) and production from the additional facilities at a rate of at least 185 short tons per month. Should bona fide orders for titanium metal sponge fall below 260 short tons per month, the Contractor may notify the Administrator stating the amount of the deficiency, and the Administrator shall have 30 days from the date of such notice to place orders for said deficiency before additional production is discontinued. The additional production shall commence immediately upon completion of the additional facilities, the time for such completion being hereafter more fully set forth in Article II of this contract.

ARTICLE II. ADDITIONAL FACILITIES

1. The additional facilities to be provided by the Contractor hereunder shall have a designed productive capacity of 2700 short tons per annum of titanium metal sponge and shall consist generally of, but not be restricted to, the following: improvements, additions, and alterations of and to present buildings and other fixed installations at Contractor's existing titanium metal facilities located at Newport, Delaware, and at Contractor's existing titanium tetrachloride facilities located at Edge Moor, Delaware, and necessary machine tools, furnaces, and other machinery and equipment required in connection with production from the additional facilities. Prior to the acquisition of the additional facilities, the Contractor shall submit to the Administrator (i) a written description of the additional facilities and the process for their operation, which description need not contain confidential information of the Contractor, and (ii) lists of property to be procured. It is estimated that the total cost of the additional facilities, including related construction expense and engineering fees, will not exceed $14,700,000. Said cost is on the basis of an 8-hour day and a 48-hour week. The Contractor shall not be required or expected to work longer hours unless the Administrator shall first agree to an increase in the total amount of advances made available under Article V of this contract to cover the increase in cost due to premium pay for overtime. The additional facilities will be neither complete nor independent plants but will be partial facilities integrated with existing facilities so as to provide expansion of productive capacity and auxiliary and service functions. It is understood and agreed that after the additional facilities are installed, the existing titanium tetrachloride facilities and the additional titanium tetrachloride facilities will be operated during the term of this contract as completely integrated facilities with increased capacity for production of titanium tetrachloride available to support the additional production of titanium metal sponge. However, it will be practicable for the Contractor to measure semi-finished titanium metal sponge production from its existing titanium metal sponge production lines and to measure semi-finished additional production from the additional titanium metal sponge production lines constructed under this contract. The semi-finished titanium metal sponge, after leaving the production lines, will be commingled in the finishing operations and the finished product will be allocated to production from existing facilities and to production from the additional facilities in the same proportion as the measured semi-finished production.

2. The Contractor shall purchase, manufacture, assemble or otherwise acquire materials, equipment, supplies and all other things needful for or pertaining to the additional facilities in its own name and in accordance with its usual commercial practices, and title to everything so acquired shall be in the Contractor. The additional facilities shall be completed in the shortest time practicable, but in no event later than 29 months after the date first hereinabove written (subject, however, to Article XI (Force Mayeure)). The Contractor shall advise the Administrator, in writing, of the date that the facilities are completed hereunder. In addition, the Contractor's training of operating personnel and necessary preliminary operation of the manufacturing facilities will proceed as rapidly as possible without waiting for the completion of the construction and installation activities in connection with said additional facilities. Design and engineering work performed on and after January 13, 1951 and materials and equipment ordered by the Contractor on and after January 1, 1952 in anticipation of this contract shall be considered as work hereunder and as capital investment charges.

ARTICLE III. DISPOSITION OF ADDITIONAL PRODUCTION

1. Commencing with the date when the additional facilities are capable of producing approximately 1350 short tons of titanium metal sponge annually (which may or may not be prior to the completion of said facilities) and continuing thereafter until the termination or completion of this contract, and subject to priority delivery as may be required pursuant to law, the Administrator may require the Contractor to sell to the Government, or for its account, all or any part of the first 75 tons of such titanium metal sponge produced from the additional facilities by the Contractor thereafter during any calendar quarter. The Contractor shall advise the Administrator, in writing, of the date the additional facilities are capable of producing said 1350 short tons annually. In the event the Administrator desires to exercise his rights pursuant to this paragraph 1, he shall furnish the Contractor with written notice thereof at least thirty (30) days prior to the commencement of each such calendar quarter.

2. Commencing with the date when the additional facilities are capable of producing approximately 1350 short tons of titanium metal sponge annually (which may or may not be prior to the completion of said facilities) and continuing thereafter until the termination or completion of this contract, and subject to priority delivery as may be required pursuant to law, the Contractor shall offer and make available for sale to industry, at its lowest market price for corresponding grades and quantities in effect at the time of delivery, all of its additional production during each calendar quarter except for that portion of each calendar quarter production from the additional facilities purchased by the Government pursuant to paragraph 1 next above.

3. As to any calendar quarter after the date that the additional facilities provided for hereunder are completed, as defined in Article II, 2 of this contract, the Administrator shall have the right, on thirty (30) days' written notice prior to the beginning of each such calendar quarter, to require the Contractor to sell to the Government the difference, if any, between the actual capacity of the additional facilities not to exceed 675 short tons of titanium metal sponge and the quantity of such material disposed of by the Contractor pursuant to paragraphs 1 and 2 above during the said calendar quarter.

4. While any portion of any advance made to the Contractor by the Government under Article V of this contract, with interest thereon, remains unpaid, the Contractor may tender to the Government and the Government shall accept any quantity not in excess of 675 short tons of the additional production not disposed of in accordance with paragraphs 1, 2 and 3 of this Article III and not otherwise sold or utilized by the Contractor during any calendar quarter. Each such tender pursuant to this paragraph 4 shall be made in writing by the Contractor within thirty (30) days after the end of each such calendar quarter, stating the quantity to be so delivered and the date of delivery thereof. Upon repayment in full of the Contractor's indebtedness to the Government for all advances made hereunder, together with accrued interest thereon, all rights of the Contractor pursuant to this paragraph 4 shall cease.

5. Titanium metal sponge delivered to the Government pursuant to any provision of this contract shall be a porous form of titanium metal having a sufficiently low impurity content (as hereinafter specified) to contain at least 99.3 percent pure titanium, conforming to the following specifications:

Chemical analysis

Titanium content	99.3 percent minimum.
Impurities:	
Iron	.25 percent maximum.
Nitrogen	.03 percent maximum.
Chlorine	.15 percent maximum.
Magnesium	.10 percent maximum.
Carbon	.05 percent maximum.
Maximum total impurities	.7 percent.

The hardness after arc melting in an inert atmosphere shall be less than Brinell 203.

As further commercial experience is developed, the specification requirements of this Article may be modified by mutual agreement of the Contractor and the Administrator.

ARTICLE IV. PRICE

The price for titanium metal sponge which the Contractor shall sell to the Government under any provision of this contract shall be the lower of:

1. $5.00 per pound, or

2. The average monthly market price per pound for titanium sponge of the same quality and quantity for the month in which delivery of such sponge is made as is quoted by the Engineering and Mining Journal, Metal and Mineral Markets, or such authoritative successor publication as may be agreed upon by the Contractor and the Administrator.

ARTICLE V. ADVANCES AND POUNDAGE PAYMENTS

For the purpose of assisting the Contractor in its obligations hereunder, the Government will, upon the Contractor's written request, advance to the Contractor hereunder from time to time sums of money needed for the design, acquisition, and installation of the additional facilities which may total but shall not exceed $14,700,000. Such advance payment(s) will be made, retained, used, and repaid in accordance with the following terms and conditions:

1. Advance payments will bear interest at the rate of 4 per cent per annum on the unpaid balance from the date of advance and interest shall be accrued on each advance payment made hereunder on the basis of a 365- (or 366-) day year. Interest accruing during the construction period of the additional facilities hereunder on any advance payment made to the Contractor pursuant to this contract shall be due on the last day of each calendar quarter and shall be payable within ten (10) days after the due date. For the purposes of this paragraph 1, the construction period shall end with the first production of titanium metal sponge from the additional facilities.

2. All moneys advanced pursuant to this contract shall be used by the Contractor exclusively for providing operable additional facilities including design, acquisition, and tested installation.

3. All moneys advanced to the Contractor hereunder shall be deposited by the Contractor in a separate bank account in a bank to be approved by the Administrator. The Contractor shall not commingle such funds with any other funds.

4. Each request of the Contractor for an advance payment hereunder will be supported by a cash flow sheet showing the Contractor's requirements for funds to be advanced. Funds shall be advanced at a rate such that the unexpended balance of funds advanced shall be sufficient for the next sixty (60) days' estimated requirements. As the installation of the additional facilities progresses, the Contractor will also furnish a statement of cumulative cost in such detail as the Administrator may reasonably request. As soon as practicable after final closing of the construction project for the additional facilities, the Contractor shall refund to the Government any excess in advances over total costs of the additional facilities.

5. The Government shall have a claim, paramount to that of all others, upon all property acquired or contracted for by the Contractor in connection with the performance of this contract and for which all or any part of such advance payment(s) is used and upon the credit balance in the separate bank account or accounts in which said advance(s) may be deposited.

6. The Contractor covenants that it will keep the additional facilities free of any liens or encumbrances other than the Government's claim on the additional facilities during the term of this contract.

7. The Contractor will provide and maintain at its own expense fire and extended coverage insurance policies with companies acceptable to the Administrator on the additional facilities in an amount at least equal to the amount of the unpaid balance of advances under this contract and accrued interest thereon. The Contractor shall restore the additional facilities in the event of loss or damage covered by said insurance policies whether or not the proceeds from such insurance is sufficient to cover the cost of such restoration.

8. In the event that any part or process of the additional facilities shall become partially or wholly obsolescent, or in the event any improvement in equipment or process is hereafter devised which is deemed by the Contractor to be advantageous, and if, incidentally thereto, replacement, acquisition, or addition of equipment or process is required, the Contractor shall have the right to apply to the Administrator for approval of such replacement, acquisition, or addition to such equipment or process. The Administrator shall have the right to approve or reject, in whole or in part, any such recommended change in

equipment or process. In case the Administrator approves any such change, the Government will advance to the Contractor such supplemental funds as may be necessary to defray the cost of such change and such supplemental advances may be made, if necessary, without regard to the maximum limitation of $14,700,000 hereinabove provided in this Article V. Such supplemental advances, shall be added to the unpaid balance of the original advances and there shall be deducted from such adjusted unpaid balance of advances an amount equal to the installed cost of any facilities retired in connection with such improvements, less:

(*a*) accelerated amortization on such retired facilities allowable by the Bureau of Internal Revenue by reason of the certificate of necessity covering the additional facilities issued pursuant to Section 124A of the Internal Revenue Code, as amended;

(*b*) such other depreciation as may be allowable by the Bureau of Internal Revenue for any part of such retired facilities for which accelerated amortization was not authorized.

The Contractor shall transfer to the Government and the Government shall take title to such retired facilities and the Government shall promptly remove the same from the contractor's sites; provided that the contractor shall assist the Government, at its request, in getting bids for the sale and removal of such retired facilities. It is not the intention of the parties hereto, should any supplemental advance be made hereunder, that this contract will be changed in any way to result in a reduction of productive capacity of the additional facilities to less than 2,700 short tons annually of titanium metal sponge.

9. All advances hereunder, with interest thereon (except interest paid pursuant to paragraph 1 of this Article V), will be repaid by the Contractor by the payment to the Government of poundage payments. Said poundage payments shall be made upon the production of each and every pound of salable titanium metal sponge produced from the additional facilities and shall begin to accrue with the first production of titanium sponge from the additional facilities. The Contractor shall advise the Administrator, in writing, of the date that the first batch of titanium metal sponge is produced from the additional facilities.

10. The aforesaid poundage payments shall, subject to the provisions of paragraphs 12 and 13 of this Article V and of Article VIII of this contract, be at the rate of $0.61 for each and every pound of salable titanium metal sponge produced from the additional facilities, and shall continue until June 30, 1962, or until all advances with interest thereon, are repaid, whichever event first occurs.

11. Poundage payments may be made in cash or by tender of titanium metal sponge (at a value equal to the price as calculated pursuant to Article IV hereof) or in any combination of cash and titanium metal sponge and all such payments shall be credited first against the interest accrued to the date of payment and then against the unpaid principal. Poundage payments due shall be determined as of the close of each calendar quarter and shall be paid within sixty (60) days after the close of such calendar quarter. The Contractor may pay all or any part of the advances, in cash or in titanium metal sponge or any combination thereof, in advance at any time and interest shall thereupon cease upon the principal so paid. Contractor may, in making any such payments in advance, specify, if it so desires, that such payment shall be deemed to be payment in advance of poundage payments to accrue in the future, and thereupon further poundage payments shall not again become due upon future production until a number of pounds of titanium metal sponge have been produced upon which the poundage payments are equal to the payments so made by Contractor in advance; and thereafter poundage payments shall again become due upon further production.

12. If when the final closing of the construction project for the additional facilities has been made and any excess in advances has been refunded to the Government, the net advances made to Contractor by the Government under the provisions of this Article V, is less than $14,700,000, then the rate of poundage payments hereinbefore set forth as $0.61 shall be proportionately reduced thenceforth.

13. If there are any supplemental advances pursuant to paragraph 8 of this Article V, the rate of poundage payments provided in paragraph 10 of this Article V will be adjusted, if necessary, beginning with start of operation of the improved facilities, to insure full repayment to the Government of the unpaid advances hereunder, with interest, over the period of production of such part of 13,500 tons of titanium metal sponge as has not then been produced with the additional facilities.

ARTICLE VI. PAYMENT

1. The Government shall, except as provided in paragraph 2 next hereinafter, pay for all titanium metal sponge, which the Contractor shall sell to the Government under any provision of this contract, the purchase price determined in accordance with Article IV of this contract.

2. The Government shall, for titanium metal sponge tendered to it by the Contractor under paragraph 4 of Article III of this contract, credit the value of such material at the price determined in accordance with Article IV of this contract against the balance of the Contractor's indebtedness for advances and accrued interest thereon, such credit being first applied to accrued interest and then to the principal.

3. Payment for each lot of material delivered by the Contractor hereunder shall be made promptly upon presentation by the Contractor of its properly certified invoice, supported by a certified weight certificate, a certified analysis report, a signed copy of the bill of lading or storage certificate or certificates on Government Receiving Form and such other documents and reports as may reasonably be required by the Administrator. Each such invoice shall be prepared and submitted in triplicate, shall contain a reference to the contract number of this contract, the quantity, unit price and extended total and shall contain the following certificate, signed by the Contractor or his authorized representative:

"I certify that the above bill is correct and just and that payment therefor has not been received."

ARTICLE VI. DELIVERY

All titanium metal sponge to be delivered to the Government hereunder shall be delivered f. o. b. common carrier conveyance, Contractor's plant at Newport, Delaware, and title shall pass upon issuance to the Administrator of a signed bill of lading. The Contractor shall furnish the Administrator with at least fifteen (15) days' written notice of each lot of material to be delivered hereunder in order that appropriate shipping instructions may be supplied by the Administrator. All material delivered to the Government pursuant to this contract shall be prepared for shipment in accordance with the Contractor's usual methods for packing and shipping similar material. In the event the Administrator shall fail to supply shipping instructions within fifteen (15) days after having been notified as hereinabove provided, title shall pass to the Government upon isssuance of a storage certificate by the Contractor to the Administrator in form substantially as shown in Appendix A attached to and made a part of this contract. Thereafter such material shall be stored at the expense and risk of the Government. The Contractor shall, without additional expense to the Government, act as forwarding agent for the Government, effecting shipment of all deliveries in accordance with instructions to be furnished by the Administrator and processing all necessary shipping documents. This service shall be performed not only with regard to materials delivered on schedule but also with regard to materials which shall be stored at the expense and risk of the Government and concerning which shipping instructions are thereafter received during the term of this contract.

ARTICLE VIII. TERMINATION

1. *Termination Rights of Administrator.*—The Administrator may, for the convenience of the Government, terminate the work of the Contractor under this contract at any time before the date of completion (as defined in Article II of this contract) of the additional facilities in accordance with the procedure hereinafter set forth.

2. *Termination Rights of the Contractor.*—The Contractor may terminate its work under this contract in accordance with the procedure hereinafter set forth upon the happening of any one of the following events:

(*a*) If, despite due diligence on the Contractor's part, the Contractor is unable, within sixty (60) days from the date first hereinabove written, to obtain, pursuant to Section 124A of the Internal Revenue Code, as amended, a certificate of necessity covering not less than 90 percent of the cost of the additional facilities (termination under this subparagraph (*a*) to be without cost or expense to Government);

(*b*) If the Contractor is not able to obtain utilities, materials, supplies, equipment or manpower for the construction or operation of the additional facilities

by reason of any action or failure to act on the part of the Government, or any agency thereof, and if such condition is not remedied within sixty (60) days after written notice of such condition to the Administrator;

(*c*) By reason of lack of demand for titanum metal sponge, the Contractor is not required to operate the additional facilities under Article I of this contract;

(*d*) The additional facilities become obsolescent.

The determination that the additional facilities are obsolescent for the purpose of this Article VIII shall be made by the Administrator in accordance with the following procedure which shall apply only to the period after the additional facilities are capable of producing 185 short tons per month of titanium metal sponge:

As soon as the Contractor shall determine that the additional production during any calendar month has been at a loss, the Contractor shall so notify the Administrator.

When the Contractor shall determine that the additional production for any period of four months has been at a loss for the said period as a whole, the Contractor may report to the Administrator the costs, production, sales, and a profit and loss statement concerning the additional production for said four months period. Thereupon, within thirty (30) days the Administrator shall make such audit of the Contractor's records of cost, production and sale of titanium sponge produced in the additional facilities for the period of the contract as he deems necessary and shall determine whether or not the facilities are obsolescent. He shall determine that the additional facilities are obsolescent, if he finds that the additional production for said period of four months has been at a loss. Failure of the Administrator to give the Contractor written notice of his decision within said thirty (30) days shall constitute a determination that the facilities are obsolescent.

3. *Procedure for Termination before Completion of Additional Facilities.*—(*a*) Before the date of completion (as defined in Article II, of this contract) of the additional facilities, termination shall be by written notice from one party to the other ten (10) days in advance of its effective date.

(*b*) Thereupon the Contractor may elect (i) to retain title to all or any part of the additional facilities and pay promptly to the Government all advances plus unpaid interest thereon related to the retained facilities, or (ii) to discontinue work on all or any part of the additional facilities (hereinafter called the "discontinued facilities"). Upon payment to the Government of all advances plus unpaid interest thereon related to the retained facilities, all obligations of the Contractor to the Government under this agreement with regard to the retained facilities and the advances and interest related thereto shall cease.

(*c*) With regard to the discontinued facilities, interest on advances shall cease on the effective date of termination and:

(1) The Contractor shall take prompt steps to stop all procurement, installation and construction work, to cancel all commitments, to settle all claims, to segregate and store all materials and equipment procured for the work, to dismantle and store all equipment already installed, to tear down and salvage all construction; provided, that settlement of claims shall be subject to the approval of the Administrator and the defense of any claims or suits which cannot be settled with the approval of the Administrator may be carried out by the Government at its option;

(2) The Contractor shall transfer to the Government and the Government shall take title to all such stored, dismantled and salvaged equipment and materials and the Government shall promptly remove the same from the Contractor's sites, and if the Government shall fail to remove the same within three months after written notice from the Contractor, the Contractor may store the same off its sites at Government expense. Within sixty (60) days after the determination of the Contractor's costs as set forth in the following items and their audit by the Government, the Contractor shall pay to the Government the amount by which advances and any unpaid interest thereon related to discontinued facilities exceed the said costs or the Government shall pay to the Contractor the amount by which the said costs exceed said advances and any unpaid interest thereon:

(a) The cost of design, acquisition, construction and installation of the discontinued facilities.

(b) The cost of settling claims for labor, materials, services and utilities cancelled because of termination.

(c) The cost of dismantling equipment, tearing down and salvaging the construction, storing of materials, equipment and salvage.

Upon transfer of title to the Government of the discontinued facilities and settlement of related advances and interest, all obligations of the contractor to the Government under this agreement with regard to the discontinued facilities and the advances and interest related thereto shall cease.

4. *Procedure for Termination After Completion of Additional Facilities.*—(*a*) After the date of completion (as defined in Article II of this contract) of the additional facilities, termination shall be by written notice from the contractor to the Administrator thirty (30) days in advance of its effective date.

(*b*) The Government shall purchase all titanium metal sponge, produced in the additional facilities subsequent to the date of issuance of the notice specified in subparagraph a. hereinabove, not to exceed 185 short tons, not sold to others and shall pay the Contractor therefor the price determined in accordance with Article IV of this contract.

(*c*) The Contractor shall promptly pay the Government any due and unpaid poundage payments and such poundage payments shall be credited first against interest accrued to the effective date of termination and then against unpaid principal.

(*d*) The Contractor may elect to retain title to all (but not part) of the additional facilities located at Contractor's Edge Moor, Delaware plant. As to facilities which the Contractor retains pursuant to this subparagraph d, the Contractor shall pay to the Government either in cash or in titanium metal sponge at prices determined in accordance with Article IV of this contract, or any combination of the two, that part of the unpaid advance and interest thereon applicable to such retained facilities. For this purpose poundage payments made by the Contractor, after excluding any portion of such poundage payments credited against interest accrued, shall apportioned to the facilities at the respective locations proporationate to unpaid advances immediately preceding each such poundage payment. Upon payment to the Government of the unpaid advance and interest thereon related to such retained facilities, all obligations of the Contractor to the Government under this agreement with regard to such retained facilities and the advances and interest related thereto shall cease.

(*e*) The Contractor may elect to retain such additions or alterations of and to present buildings and other fixed installations (not retained under subparagraph d. next hereinabove) as are useful to it at an agreed fair value. Upon payment to the Government of the agreed fair value either in cash or in titanium metal sponge at prices determined in accordance with Article IV of this contract, or any combination of the two, all obligations of the Contractor to the Government under this agreement with regard to such retained facilities and the advances and interest related thereto shall cease.

(*f*) The Contractor shall tender to the Government all of the additional facilities which the Contractor does not retain pursuant to subparagraphs d. and e. next hereinabove. The Government shall accept such tender and shall, within a period of eighteen months, at the expense of the Government dismantle and remove all of the additional facilities tendered to it (except that, at its option, the Government may abandon underground installations) and the Government shall not be or become liable for the use or occupancy of any space or buildings during said eighteen months period but the additional facilities tendered the Government shall after such tender remain on Contractor's sites at the risk of the Government. Upon such tender to the Government all obligations (except those set forth in subparagraph g. next hereinafter) of the Contractor to the Government under this contract with regard to such tendered facilities and the advances and interest related thereto shall cease.

(*g*) Should the Government undertake to rebuild the additional facilities, located at the Contractor's Newport, Delaware plant, for the production of titanium metal sponge from titanium tetrachloride and magnesium at a new location, the Contractor shall supply to the Government, or its nominee, operating instructions for these facilities. Upon request by the Government, or its nominee, the Contractor shall supply technical assistance in connection with the start-up and operation of these facilities at a consultation fee of $50 per man per day plus transportation and not to exceed $15 per diem in lieu of subsistence and other expenses while away from his regular place of business; provided that such technical assistance shall not exceed 250 man-days and shall not extend beyond June 30, 1962. The additional facilities for the production of titanium tetrachloride at the Contractor's Edge Moor, Delaware plant will lack so many essentials of a complete unit that these facilities cannot be relocated

as a production unit. Accordingly, the Contractor shall not be required to supply operating instructions or technical assistance in connection with these facilities.

5. Whenever, under the provisions of this Article VIII, each party shall be required to make payments to the other party, the respective amounts shall be set off against each other and the difference shall be paid by the party owing the larger amount.

ARTICLE IX. BOOKS AND RECORDS

1. The Contractor will maintain separate records concerning (i) the receipt and disbursement of the funds advanced by the Government hereunder; (ii) the progress of construction of the additional facilities; and (iii) costs and expenses incurred in connection with any termination under Article VIII of this contract. The Contractor will furnish the Government a quarterly report of the aforesaid items as soon as practicable after the end of each calendar quarter.

2. The Contractor will maintain separate records of the quantities of titanium metal sponge produced from the additional facilities and will furnish the Government a quarterly report of such production within sixty (60) days after the end of each calendar quarter.

3. As soon as practicable after the end of each calendar year, until the terms of this agreement have been completed, the Contractor shall submit the records and reports required by paragraphs 1 and 2 of this Article IX to an Independent Public Accountant selected by the Contractor and acceptable to the Administrator. The Independent Public Accountant shall audit such reports and shall report his findings to both the Government and the Contractor.

4. Prior to the execution of this agreement, the Administrator has satisfied himself of the soundness of the Contractor's regularly employed methods of computing the capital costs of new facilities constructed by it, including, but not limited to (i) the charging of salaries of certain groups of the Contractor's central Engineering Department on the basis of an average salary rate (ii) the distribution of indirect costs and overhead expenses of the Contractor's central Engineering Department, Purchasing Department and Treasurer's Department (iii) the distribution of the costs of plant services provided to the project, and (iv) the furnishing of tools, machinery, equipment and supplies of its own manufacture and building space owned by it at prices consistent with those regularly employed by the Contractor in its commercial construction projects. It is expressly understood and agreed that the Contractor's regularly employed methods of computing the capital costs of new facilities constructed by it shall be accepted by the Government in establishing the costs of the additional facilities.

5. The Government shall have access to the records referred to in paragraphs 1 and 2 of this Article IX and also the accounting records and documents supporting the construction costs of the additional facilities to determine whether such costs are based upon the application of the methods described in paragraph 4 of this Article IX. Such records and documents shall be available to the Government at all reasonable times for audit and examination and the Contractor will retain such records until three years after expiration of this contract.

ARTICLE X. DURATION OF CONTRACT

Except as it may be modified by the provisions of Article VIII of this contract, the term of this contract shall extend from the effective date hereof until the occurrence of any one of the following, whichever is first:

1. The production hereunder by the Contractor of 13,500 short tons of titanium metal sponge, coupled with the full repayment by it of all advances made to it by the Government, together with interest thereon, or

2. June 30, 1962.

In the event the contract terminates under paragraph 2 above and complete repayment of all moneys advanced by the Government, with interest accrued thereon, has not been made by the Contractor, such unpaid balance shall be immediately due and payable.

ARTICLE XI. FORCE MAJEURE

The time for performance by the Contractor of its obligations under the provisions of this contract relating to the completion of the additional facilities, the

operation of the additional facilities, or the production and delivery of titanium metal sponge from such additional facilities, shall be extended at the Contractor's option by a time or times equivalent to any delay, interruptions or cessations occasioned by force majeure (herein defined as any cause which is beyond the Contractor's reasonable control, including, without limitation, acts of God, strikes, fires, storms, sabotage, acts of war or public enemy, and priority or allocation requirements or other acts of the Federal Government), provided that the Contractor shall give to the Administrator, within ten (10) days after the occurrence of such force majeure, written notice thereof, together with a statement setting forth the facts evidencing such force majeure and further provided that at the conclusion of the duration of such force majeure the Contractor shall, within ten (10) days thereafter, notify the Administrator in writing of the termination of such force majeure, provided, however, that no force majeure condition shall extend the duration of this contract beyond June 30, 1962.

ARTICLE XII. GOVERNMENT CONTROLS

The Administrator covenants that he will use all reasonable efforts to assist the Contractor in obtaining priorities or allocations for scarce or controlled materials, supplies, equipment and manpower.

ARTICLE XIII. INSPECTION

1. Sampling and examination for physical condition shall be performed concurrently at the Contractor's plant by representatives of the Contractor and the Administrator. Sampling and analysis shall be conducted in conformity with the methods and procedure set forth in Appendix B attached hereto and made a part hereof. Appendix B may be revised, from time to time, by mutual agreement of the parties hereto without formally amending this contract. The Administrator shall be notified at least ten (10) days in advance of scheduled sampling. Inspection by the Government shall be performed in such a manner as not to interfere with production or processing operations, and the Government shall be accorded full cooperation of the Contractor. The sample collected according to approved methods as specified above shall be prepared in three (3) equal parts, each packaged, sealed, identified and distributed as follows: One (1) to the Contractor, for its analysis, and two (2) to the Government. One of the latter is for analysis by the Government or its agent, and the other retained for use as an umpire sample if needed.

2. In the event of a disagreement with respect to the chemical analysis or hardness test, the umpire sample shall be submitted to an acceptable umpire. The final result with respect to each determination shall be the middle result of the three determinations, that of the Contractor, that of the Government and that of the umpire.

Such costs as may be incurred in connection therewith shall be paid by the party against whom the determination is made.

For umpire determinations, the following laboratories are acceptable to the Contractor and the Government: Rem-Cru Titanium Inc., Republic Steel Corp., P. R. Mallory Company, W. B. Coleman & Company, or such other laboratories as may be hereafter mutually agreed upon by the Administrator and the Contractor.

3. The Contractor's certified weight certificate shall govern as to quantity. Cost of weighing, if any, shall be for the Contractor's account. The Administrator reserves the right to check weigh any or all drums opened for sampling and, should errors in weight be found, the actual weight of the lot shall be determined and shall govern.

4. The Government may reject all material which does not comply with contract requirements, and it shall be reimbursed by the Contractor for all costs incurred by the Government in connection with the rejected material; provided, however, that the Contractor's chemical analysis and hardness tests shall be submitted to the Government, shall be binding and conclusive on the Government and the Government shall finally accept all material which, on the basis of such analysis and tests, meets the contract requirements, unless the Administrator shall notify the Contractor in writing, within twenty (20) days of the date samples are taken, that there is disagreement between the chemical analysis and hardness tests made by the Government and those made by the Contractor which will necessitate that umpiring procedure under paragraph 2 of this Article XIII shall be followed.

ARTICLE XIV. BUY AMERICAN ACT

The Contractor agrees that there will be delivered under this contract only such unmanufactured articles, materials, and supplies (which term "articles, materials, and supplies" is hereinafter referred to in this clause as "supplies") as have been mined or produced in the United States, and only such manufactured supplies as have been manufactured in the United States substantially all from supplies mined, produced, or manufactured, as the case may be, in the United States. Pursuant to the Buy American Act (41 U. S. Code 10a-c), the foregoing provision shall not apply (i) with respect to supplies excepted by the Administrator from the application of that Act, (ii) with respect to supplies for use outside the United States, (iii) with respect of the supplies to be delivered under this contract which are of a class or kind determined by the Administrator or his duly authorized representative not to be mined, produced, or manufactured, as the case may be, in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality, or (iv) with respect to such supplies, from which the supplies to be delivered under this contract are manufactured, as are of a class or kind determined by the Administrator or his duly authorized representative not to be mined, produced, or manufactured, as the case may be, in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality, provided that this exception (iv) shall not permit delivery of supplies manufactured outside the United States if such supplies are manufactured in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality.

ARTICLE XV. CONVICT LABOR

In connection with the performance of work under this contract, the Contractor agrees not to employ any person undergoing sentence of imprisonment at hard labor.

ARTICLE XVI. WALSH-HEALEY PUBLIC CONTRACTS ACT

If this contract is for the manufacture or furnishing of materials, supplies, articles or equipment in an amount which exceeds or may exceed $10,000 and is otherwise subject to the Walsh-Healey Public Contracts Act as amended (41 U. S. Code 35–45), there are hereby incorporated by reference all representations and stipulations required by said Act and regulations issued thereunder by the Secretary of Labor, such representations and stipulations being subject to all applicable rulings and interpretations of the Secretary of Labor which are now or may hereafter be in effect.

ARTICLE XVII. NONDISCRIMINATION IN EMPLOYMENT

In connection with the performance of work under this contract, the Contractor agrees not to discriminate against any employee or applicant for employment because of race, creed, color, or national origin; and further agrees to insert the foregoing provision in all subcontracts hereunder except subcontracts for standard commercial supplies or for raw materials.

ARTICLE XVIII. OFFICIALS NOT TO BENEFIT

No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE XIX. COVENANT AGAINST CONTINGENT FEES

The Contractor warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Contractor for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to deduct from the contract price or consideration the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE XX. ASSIGNMENT OF CLAIMS

1. The Contractor shall not, without the prior written consent of the Government, sell, assign, transfer, or pledge this contract or any of its rights, powers, privileges, duties or obligations thereunder, provided, however, that any monies due or to become due under this contract, but not including any advances made or to be made hereunder, may be assigned by the Contractor to a bank, trust company or other financing institution, including any Federal lending agency pursuant to and in accordance with the Assignment of Claims Act of 1940, as amended (31 U. S. C. 203, 41 U. S. C. 15). All rights, powers, privileges, duties and obligations under this contract shall inure to any successor or successors of Defense Materials Procurement Agency or any branch or agency of the Government to which the Defense Materials Procurement Agency shall hereafter delegate or assign its authority to act for the Government hereunder.

2. In no event shall copies of this contract or of any plans, specifications, or other similar documents relating to work under this contract, if marked "Top Secret," "Secret," "Confidential," or "Restricted," be furnished to any assignee of any claim arising under this contract or to any other person not entitled to receive the same; provided, that a copy of any part or all of this contract so marked may be furnished, or any information contained therein may be disclosed, to such assignee upon the prior written authorization of the Administrator.

ARTICLE XXI. NONWAIVER CLAUSE

The failure of either the Contractor or Government to insist in any one or more instances upon the performance of any of the terms, covenants, and conditions of this contract shall not be construed as a waiver or relinquishment of the future performance of any such term, covenant or condition by the other party hereto, but the obligation of such other party with respect to such future performance shall continue in full force and effect.

ARTICLE XXII. NOTICE

Notice to Contractor shall be sufficient if given in writing addressed to General Manager, Pigments Department, E. I. du Pont de Nemours and Company, Wilmington, Delaware, and notice to Government shall be sufficient if given in writing addressed to Defense Materials Procurement Agency, General Services Administration Building, 18th and F Streets, N. W., Washington 25, D. C., or such other address as either party for itself may specify to the other party in writing.

DEFINITIONS

ARTICLE XXIII. As used herein, the term "Administrator" means the Administrator of Defense Materials Procurement Agency, his successor or duly authorized representatives.

CONTRACT AUTHORITY

ARTICLE XXIV. This contract is entered into pursuant to the Defense Production Act of 1950, as amended (Public Law 774, 81st Congress; Public Laws 69 and 96, 82nd Congress).

IN WITNESS WHEREOF the parties hereto have executed this contract as of the day and year first hereinabove written.

UNITED STATES OF AMERICA
ACTING BY AND THROUGH
DEFENSE MATERIALS PROCUREMENT AGENCY,
By JESS LARSON,
Administrator.

E. I. DU PONT DE NEMOURS AND COMPANY,
General Manager.

Attest:

_____
(Title)

[CORPORATE SEAL]

APPENDIX A

NONNEGOTIABLE STORAGE AND OWNERSHIP CERTIFICATE

Date: _____

The undersigned Company hereby certifies that it has received and holds in storage at _____ for the United States of America acting by and through the Defense Materials Procurement Agency the following titanium metal sponge sold to the Government pursuant to Contract Number _____; dated _____ :

Lot Number _____
Weight _____
Analysis _____

and that said titanium metal sponge is identified by legible marks to indicate that it is owned by the United States of America, and that it will be stored in accordance with the aforesaid agreement and released pursuant to instructions of Defense Materials Procurement Agency.

E. I. DU PONT DE NEMOURS AND COMPANY,
By _____
Title _____

CONTRACT NO. DMP–75 BETWEEN UNITED STATES OF AMERICA AND CRAMET INC.

THIS CONTRACT, between the United States of America, acting by and through the Defense Materials Procurement Agency, its successors, assigns, and duly authorized representatives, hereinafter referred to as the "Government" (pursuant to the authority contained in the Defense Production Act of 1950, as amended, Executive Order No. 10161, as amended and supplemented, and any other enabling legislation), and Cramet Inc., a corporation organized and existing under the laws of the State of Delaware, hereinafter referred to as the "Contractor."

WITNESSETH:

In consideration of the mutual promises herein contained, the parties hereto agree as follows:

ARTICLE I. PREPARATION OF FACILITIES

Contractor shall, without delay, procure land, and construct, equip and maintain in or near Nashville, Tennessee, a plant (all hereinafter referred to as the "Facilities") capable of producing in the normal course of operation and without the use of other productive capacity, sufficient titanium sponge to meet Contractor's obligations as set forth in Article II hereof. It is understood that the Facilities include equipment for the production of titanium ingot and ingots of titanium alloys. Said Facilities shall be completed to the extent that first production can start not more than eighteen (18) months following the date of execution of this Contract. "First Production" means the first batch of titanium sponge produced by the main facilities, excluding sponge produced incidental to equipment trial runs. It is understood that construction may continue after the First Production has started, and the period of construction shall end when the Facilities included herein are completed. The plant will include facilities for the control of plant processes. The titanium sponge produced incidental to the operation of the control facilities shall not be considered for the purpose of determining the date of First Production. Production of the control facilities subsequent to First Production will, however, be included in determining total production.

ARTICLE II. PRODUCTION

Upon commencement of First Production in accordance with Article I hereof, Contractor shall commence production in such a manner as to reach and assure, within thirty (30) months after the date of execution of this Contract, a production capacity of 6,000 short tons (of 2,000 pounds avoirdupois each) of titanium sponge per annum; and said Facilities shall be kept and maintained

at all times during the term of this Contract in such condition as may be required to produce immediately titanium sponge at the rate of 6,000 short tons per annum, regardless of whether said Facilities are ever operated at said rate.

ARTICLE III. DISPOSITION OF PRODUCTION

A. Upon ninety days' prior written notice the Government may require the sale to it during any calendar month of up to twenty-five (25) percent of the production of titanium sponge, or one hundred twenty-five (125) tons, whichever is the lower; provided, however, that when the production sold the Government under Paragraph B of this Article III, plus the quantity purchased by the Government under this Paragraph A, shall aggregate 7,500 tons, the Government's right to purchase titanium sponge under this Paragraph A shall terminate.

B. The Contractor may from time to time tender to the Government and the Government shall accept such quantity of production from the Facilities not exceeding 6,000 short tons during the term of this Contract, and not more than 1,500 tons during any calendar quarter. Tender to the Government of all or any part of the production from these Facilities for any calendar month shall be made not later than ninety (90) days following the end of such month.

C. Delivery to the Government shall be in the form of titanium sponge meeting the specifications hereinafter set forth; provided that if the parties hereto agree upon mutually satisfactory specifications, conversion quantities and prices for titanium ingot, the Government may elect to take delivery in the form of titanium ingot in lieu of titanium sponge.

D. The Contractor agrees, prior to offering titanium sponge to the Government as provided above under Paragraph B, to attempt to sell such sponge to industry; provided, however, the Contractor is not required to so sell such sponge at a price lower than that provided under Article VI B as adjusted by Article VII.

ARTICLE IV. SPECIFICATIONS

Titanium sponge delivered to the Government pursuant to any provision of this Contract shall be a porous form of titanium metal containing at least ninety-nine and three-tenths (99.3) percent pure titanium, and having a sufficiently low impurity content (as hereinafter specified) and otherwise to conform to the following specifications:

	Acceptable Analysis of Lot (percent) [1]	Rejection Analysis of Blends (percent) [2]
Titanium (Ti) minimum	[3] 99.5	[4] 99.3
Iron (Fe) maximum	.15	.25
Nitrogen (N_2) maximum	.03	.03
Chlorine (Cl_2) maximum	.12	.15
Magnesium (Mg) maximum	.07	.10
Carbon (C) maximum	.05	.08
Total Impurities	.5	.7
Hardness, Maximum	170 Bhn	200 Bhn
Size	95 percent through ¼" Screen and not to exceed 1½ percent may pass a 20-mesh sieve.	

[1] Each lot, composed of several batches or blends, shall not be less than 20,400 pounds.
[2] Each blend may not exceed 25 percent of the weight of the lot of which it is a component and all blends in a lot shall have the same weight. Any blend not meeting the "Rejection Analysis of Blends" shall not be offered as part of a lot.
[3] Titanium shall be determined by difference, i. e., 100 percent minus sum of Fe, N_2, Cl_2, Mg, C, plus 0.10 percent for other impurities.
[4] Titanium shall be determined by difference, i. e., 100 percent minus sum of Fe, N_2, Cl_2, Mg, C, plus 0.12 percent for other impurities.

As further commercial experience is developed the specifications and requirements of this Article may be modified by mutual agreement of the Contractor and the Government.

ARTICLE V. WEIGHING, INSPECTION, SAMPLING AND ANALYSIS

A. Sampling and examination for physical condition shall be performed concurrently at the Contractor's plant by representatives of Contractor and the Government. Sampling and analysis shall be conducted in conformity with the methods and procedures set forth in Appendix A attached hereto and made a part hereof. Appendix A may be revised, from time to time, by mutual written agreement of the parties hereto without formally amending this Contract. The Government shall be notified at least ten (10) days in advance of scheduled sampling. Inspection by the Government shall be performed in such a manner as not to interfere with production or processing operations, and the Government shall be accorded full cooperation of the Contractor. The sample collected according to approved methods as specified above shall be prepared in three (3) equal parts, each packaged, sealed, identified and distributed as follows: One (1) to the Contractor, for its analysis, and two (2) to the Government. One of the latter is for analysis by the Government or its agent, and the other retained for use as an umpire sample if needed.

B. In the event of a disagreement with respect to the chemical analysis or hardness test, the umpire sample shall be submitted to an acceptable umpire. The final result with respect to each determination shall be the middle result of the three determinations, that of the Contractor, that of the Government, and that of the umpire.

Such costs as may be incurred in connection therewith shall be paid by the party against whom the determination is made.

For umpire determinations, the following laboratories are acceptable to the Contractor and the Government: Rem-Cru Titanium Inc., Republic Steel Corp., P. R. Mallory Co., W. B. Coleman & Co.; or such other laboratories as may be hereafter mutually agreed upon by the Government and the Contractor.

C. The Contractor's certified weight certificates shall govern as to quantity. Cost of weighing, if any, shall be for the Contractor's account. The Government reserves the right to check weigh any or all drums opened for sampling and, should errors in weight be found, the actual weight of the lot shall be determined and shall govern.

D. The Government may reject all material which does not comply with the Contract requirements, and it shall be reimbursed by the Contractor for all costs incurred by the Government in connection with the rejected material; provided, however, that the Contractor's chemical analysis and hardness tests shall be submitted to the Government, shall be binding and conclusive on the Government and the Government shall finally accept all material which, on the basis of such analysis and tests, meets the Contract requirements, unless the Government shall notify the Contractor in writing, within twenty (20) days of the date samples are taken, that there is disagreement between the chemical analysis and hardness tests made by the Government and those made by the Contractor which will necessitate that umpiring procedure under Paragraph B of this Article V shall be followed.

ARTICLE VI. PRICE

A. The price for titanium sponge sold to the Government under Article III A hereof shall be (1) for sponge produced during the first year of production—$5.00 per pound, (2) for the remainder—$4.00 per pound (the prices as set forth above to be increased by the amount of any increase in royalty payments for the use of the Kroll Process over that set forth in the Department of Justice schedule attached hereto as Appendix B and made a part hereof), f. o. b. common carrier's conveyance, Contractor's plant, or the average monthly market price per pound for sponge of the same quality and quantity for the month in which delivery of such sponge is made as is quoted by the Engineering and Mining Journal, Metal and Mineral Markets, or such authoritative successor publication as may be agreed upon by the Contractor and the Government, whichever is higher.

B. The price of titanium sponge sold to the Government under Article III B hereof shall be on the basis of f. o. b. common carrier's conveyance, Contractor's plant, as follows: (1) for sponge produced during the first year of production, but not exceeding 1,000 short tons—$5.00 per pound; (2) for the remainder—$4.00 per pound. The prices set forth in this Paragraph B are to be increased by the amount of any increase in royalty payments for the use of the Kroll Process over that set forth in the Department of Justice schedule set forth in Appendix B attached hereto and made a part hereof.

ARTICLE VII. ESCALATION

A. The prices referred to in Article VI hereof shall be increased or decreased, as the case may be, on the basis of the following estimated direct operating costs for the base month of February 1953, hereinafter referred to as the "base month":

	Per lb. of titanium sponge
Labor	$0.66
Materials	1.33
Total	1.99

B. The amounts itemized in Paragraph A above will be adjusted as of the end of March, June, September and December of each year. The basis for the adjustment will be the corresponding amounts multiplied by: (a) Labor—the percentage of change from the base month to the last month of the quarter in Index of Average Hourly Earnings for the industry designated as "Chemicals and Allied Products" as published monthly by the U. S. Department of Labor, Bureau of Labor Statistics; (b) Materials—the percentage of change from the base month to the last month of the quarter in the Index of Wholesale Prices (1947–49=100) for the group designated as "Metals and Metal Products", as published monthly by the U. S. Department of Labor, Bureau of Labor Statistics; provided, however, that in computing such adjustments, fractions will be disregarded in that fractional increases of less than ½¢ will be dropped and fractional increases of ½¢ or more will be rounded out to the next 1¢. The aggregate of the direct operating cost adjustments as calculated above will increase or decrease, as the case may be, the prices specified in Article VI by an equivalent amount. The adjustment will be effective with deliveries made in the quarter following the next succeeding quarter after the month of the indices.

ARTICLE VIII. DELIVERY

All titanium sponge to be delivered to the Government hereunder shall be delivered f. o. b. common carrier's conveyance, Contractor's plant at or near Nashville, Tennessee, and title thereto shall pass to the Government upon issuance to the Government of a signed bill of lading. The Contractor shall furnish the Government with at least fifteen (15) days' written notice of each lot of material to be delivered hereunder in order that appropriate shipping instructions may be supplied by the Government. All material delivered to the Government pursuant to this Contract shall be prepared for shipment in accordance with the Contractor's usual methods for packing and shipping similar materials.

In the event the Government shall fail to supply shipping instructions within thirty (30) days after having been notified as hereinabove provided, title shall pass to the Government upon issuance of a storage certificate by the Contractor in form satisfactory to the Government. Thereafter, such material shall be adequately and securely stored at the expense and risk of the Government; provided, however, that to the extent storage space is available on premises owned or controlled by Contractor, Contractor will store any titanium sponge with respect to which the Government has failed to supply shipping instructions on said premises free of cost to the Government for a period not exceeding sixty (60) days. Any handling expense over and above the normal expense of handling to common carrier shall be for the account of the Government. For the purposes of this Contract, titanium sponge so stored will be considered delivered.

The Contractor shall without additional expense to the Government, act as forwarding agent for the Government, to effect shipment of all deliveries in accordance with the instructions to be furnished by the Government and process all necessary shipping documents. This service shall be performed not only with regard to materials delivered on schedule, but also with regard to materials which shall be stored at the expense and risk of the Government and concerning which shipping instructions are thereafter received during the term of this Contract.

ARTICLE IX. PAYMENT

Payment for each lot of material delivered by the Contractor hereunder shall be made promptly upon presentation by the Contractor of its properly certified

invoice, supported by a certified weight certificate, a certified analysis report, a signed copy of the bill of lading or storage certificate or certificates, as the case may be, and such other documents and reports as may reasonably be required by the Government. Each invoice shall be prepared and submitted in triplicate, shall contain a reference to the contract number, the quantity, unit price, and extended total, and shall contain the following certificate, signed by the Contractor or its duly authorized representative:

"I certify that the above bill is correct and just and that payment therefor has not been received."

ARTICLE X. ADVANCES AND POUNDAGE PAYMENTS

For the purpose of assisting the Contractor in the performance of its obligations hereunder, the Government shall promptly, upon the Contractor's written request made pursuant to the terms of this Contract, advance to the Contractor from time to time for the construction of the Facilities, sums of money which may total but shall not exceed $24,950,000. Such advance payment(s) shall be made, retained, used, and repaid in accordance with the following terms and conditions:

1. Advance payments shall bear interest at the rate of five (5) percent per annum on the unpaid balance from the date of the advance, and interest shall be accrued on each advance payment made hereunder on the basis of a 365- (or 366-) day year. The advance payment or payments shall be evidenced by a note or notes of the Contractor, payable no later than February 28, 1961. Said note or notes are to be secured by a valid first and paramount mortgage lien (1) upon all machinery and equipment acquired or installed by the Contractor with advances made hereunder; (2) upon all of the Contractor's interest in and to the land and buildings on which the Contractor's Facilities are located; (3) upon all of the Contractor's interest in and to all removable buildings and building installations acquired or constructed by the Contractor hereunder with the proceeds of any advance or advances made hereunder; and (4) upon the credit balance in the separate bank account or accounts in which the said advance payments may be deposited. Said mortgage shall also be extended to include all replacements of previously acquired installations in or additions to said Facilities, including but not limited to replacement by Contractor at its expense of obsolete equipment; provided, however, that any special buildings or equipment constructed at Contractor's expense, and readily identifiable as separate from and not a part of said Facilities, shall be exempt from the mortgage provisions of this Paragraph. Said note or notes and mortgage shall be in form and substance satisfactory to the Government. Interest accruing during the construction period of the Facilities on any advance payment made hereunder shall be added to the principal and thereafter interest shall be accrued on the sum thereof. For the purposes of this Article, the construction period shall end when Facilities are completed, capable of a production capacity at the annual rate of 6,000 tons, or the expiration of thirty (30) months from the date of this Contract, whichever event first occurs. The Contractor shall advise the Government in writing when Facilities are completed.

2. All moneys advanced hereunder shall be used by the Contractor solely and exclusively for the purposes of this Contract.

3. All moneys advanced hereunder shall be deposited by the Contractor in a separate bank account in a bank or banks to be approved by the Government. The Contractor shall not commingle such funds with any other funds.

4. Each request for an advance payment hereunder shall be supported by a cash flow sheet, satisfactory to the Government, showing the expenditures to be made by the Contractor from the funds to be advanced. As the installation of the Facilities progresses, the Contractor shall also furnish a monthly statement of cumulative costs in form and substance satisfactory to the Government, together with such other reports with respect to the progress of construction as the Government shall require.

5. The Contractor covenants that, during the term of this Contract, it will keep the Facilities covered by the Government's mortgage lien free of any other liens and encumbrances whatsoever.

6. The Contractor shall provide and maintain at its own expense insurance on the Facilities against fire, windstorm and such other hazards, in such amounts, and with such companies as shall be satisfactory to, or required by, the Government. The policies evidencing such insurance shall be made payable to the

Government as its interest may appear and evidence thereof, satisfactory to the Government, shall be delivered to the Government. The Contractor shall, if so requested by the Government, restore the aforesaid Facilities in the event of loss or damage covered by said insurance policies to the extent the proceeds from such insurance are sufficient to cover the cost of such restoration, and the Facilities, as restored, shall be subject to all the terms of this Contract.

7. In the event that any part or process of the Facilities shall become partially or wholly obsolescent, or in the event that any improvement in equipment or process is hereafter devised which is deemed by the Contractor to be advantageous, and if, incidentally thereto, the replacement, acquisition or addition of equipment or process is required, Contractor shall have the right to apply to the Government for approval of such replacement, acquisition or addition to such equipment or process. The Government shall have the right to approve or reject, in whole or in part, any such recommended change in equipment or process. In case the Government approves any such change, the Government shall advance to the Contractor such supplemental funds as Government deems necessary to defray the cost of such change, and such supplemental advances may be made, if necessary, without regard to the maximum limitation of $24,950,000 provided in this Article. The Facilities, as thus changed, shall be subject to all the terms of this Contract. Such supplemental advances shall be added to the unpaid balance of the original advances and there shall be deducted from such adjusted unpaid balance of advances an amount equal to the installed cost of any facilities retired in connection with such amounts less:

(*a*) Accelerated amortization on such retired facilities allowable by the Bureau of Internal Revenue by reason of the certificate of necessity covering the Facilities issued pursuant to Section 124A of the Internal Revenue Code, as amended; and

(*b*) Such other depreciation as may be allowable by the Bureau of Internal Revenue for any part of such retired facilities for which accelerated amortization was not authorized.

In case the Government does not approve any such change, Contractor may effect such change at its own expense, in which event the Facilities, as thus changed, shall be subject to all the terms of this Contract and there shall be credited against the Government's advances an amount equal to the installed cost of any facilities retired as a result of such change less the amounts provided for in subparagraphs (a) and (b) of this Paragraph 7.

The Contractor shall transfer to the Government, and the Government shall take title to, such retired facilities and the Government shall promptly remove the same from the Contractor's sites; provided, however, that the Contractor shall assist the Government, at its request, in getting bids for the sale and removal of such retired facilities. It is not the intention of the parties hereto, should any supplemental advance to be made hereunder, that this Contract will be changed in any way to result in a reduction of the productive capacity of the Facilities to less than 6,000 short tons of titanium sponge per annum.

8. All advances hereunder with interests thereon, will be repaid by the Contractor by the payment to the Government of poundage payments on a quarterly basis; payment to be made within sixty (60) days after the end of each calendar quarter. Said poundage payments shall be made upon each and every pound of salable titanium sponge produced from the Facilities and shall begin to accrue with the First Production of titanium sponge from the Facilities. The Contractor shall advise the Government, in writing, of the date that the first batch of sponge is produced from the Facilities.

Provided, however, that during the twelve months next succeeding the First Production, such payments need not exceed the amount of Contractor's cash return (as defined in Article XI Paragraph A 5 hereof) during such period. Should Contractor repay on this basis, poundage payments shall be recalculated at the end of the first year of production so as to assure the payment of a sufficient amount per pound to liquidate all advances, plus interest, through the production of the remainder of 30,000 tons of titanium sponge. All payments shall be applied first to the reduction of interest and then to principal.

9. The aforesaid poundage payments, subject to the provisions of Paragraphs 8 and 10 hereof, shall be at the rate of $0.52 for each and every pound of salable sponge produced from the Facilities.

10. If, when the final closing of the construction project for the Facilities has been made and any excess in advance has been refunded to the Government,

the net advance made to the Contractor by the Government, under the provisions of this Article, is less than $24,950,000, then the rate of poundage payments hereinbefore set forth as $0.52 shall be proportionally reduced thenceforth.

11. If there are any supplemental advances pursuant to Paragraph 7 hereof, the rate of poundage payments provided in Paragraphs 9 and 10 hereof will be adjusted, if necessary, beginning with the start of operation of the supplemental Facilities, to insure full repayment to the Government of the unpaid advances hereunder, with interest, over the period of production of such part of 30,000 short tons of titanium sponge as has not then been produced with the Facilities. Contractor may make prepayments of principal on any payment date.

ARTICLE XI. TERMINATION

A. The obligations of the parties hereunder shall cease and this Contract shall be terminated (except that the obligations of the parties hereto with respect to repayment of advances and accrued interest thereon in accordance with the terms of this Contract and the disposition of, and payment for, such quantity of titanium sponge metal as may have been produced hereunder prior to the time of such termination, shall remain in full force and effect until discharged in accordance with the terms hereof) upon the occurrence of any of the following events, whichever first shall occur:

1. The expiration of seven and one-half (7½) years from the date of execution of this Contract;

2. The production by the Contractor hereunder of 30,000 short tons of titanium sponge, in which event Contractor shall repay in full within six (6) months from date thereof the principal and interest due upon advances made hereunder;

3. The purchase by the Government hereunder of 6,000 short tons of titanium sponge under Article III B, in which event Contractor shall repay in full within six (6) months from date thereof the principal and interest due upon advances made hereunder;

4. The repayment to the Government of the advances made hereunder with interest at five (5) percent per annum;

5. The realization by the Contractor under the terms of this Contract of a cash return of $23,438,000, but not to exceed 90% of the cost of the Facilities (including interest during construction). "Cash return" for the purposes of this paragraph shall consist of the aggregate of (i) net profits realized under the terms of this Contract before deduction of dividends or amortization of fixed debt, but after deduction of taxes, and (ii) charges for expenses not entailing an outlay of cash, such as, but not limited to, depreciation, accelerated amortization, depletion, bad debt, or other valuation reserves, except that depreciation and accelerated amortization of facilities constructed or purchased by the Contractor for the purposes of this Contract without the use of Government funds shall be treated as a cash expense for the purpose of computing cash return. In this event, Contractor shall repay in full within twelve (12) months the principal and interest due upon advances made hereunder;

6. In the event Contractor is unable to obtain within sixty (60) days from date hereof a satisfactory certificate or certificates of necessity pursuant to Section 124A of the Internal Revenue Act, as amended, for not less than ninety (90) percent of the cost of the Facility subject to depreciation; or

7. In the event that (i) lack of demand or decline in market prices or obsolescence of any equipment or process as to which the Contractor reasonably requests but does not receive the Government's approval for change, or as to which the Contractor decides not to make such change at its own expense, results at any time in the Contractor's sustaining operating losses from the operation of the Facilities, or sufficient evidence is presented to indicate that such losses will occur in the future, and (ii) the Contractor so demonstrates to the satisfaction of the Government, the Contract will terminate on thirty (30) days' notice by the Contractor to the Government and the Contractor shall have the right to tender to the Government the Facilities (except such facilities as are exempted from the mortgage by Paragraph 1 of Article X) in full settlement of the remainder due upon the advance, plus unpaid interest thereon, and the Government shall be obligated to take title to and possession of such tendered Facilities in full settlement of the obligation. In the event the Contract is terminated as provided in this Paragraph 7, the Government will pay to the Contractor, a sum not exceeding $6,260,000 covering (1) all costs incurred in settling the Contractor's obligations incurred because of this Contract for the acquisition of, and

all losses incurred in the disposition of, power, titanium sponge, chlorine, carbon black and other materials and supplies and inventory in process, and (2) costs in terminating operations consisting of labor, taxes excluding income taxes, and materials, on the basis of the following estimates:

	Total loss	Loss on inventories on hand and in process	Loss on purchase commitments
Slag	$300,000	$300,000	$0
Chlorine	40,000	40,000	0
Carbon black	75,000	75,000	0
Binder	20,000	10,000	10,000
Magnesium	230,000	150,000	160,000
Inert gas	250,000	250,000	0
Supplies	350,000	300,000	50,000
TiCl4	150,000	150,000	0
Crucibles	480,000	320,000	160,000
Retorts	710,000	460,000	250,000
Repair materials	500,000	400,000	100,000
Tools and process materials	565,000	400,000	165,000
In process products	1,220,000	1,220,000	0
Total losses on inventories and purchase commitments	4,890,000	4,055,000	835,000
Loss on termination of power contract	1,200,000		
Fixed costs, other than amortization, during period of liquidation (45 days):			
Labor	40,000		
Taxes, etc. (excl. income taxes)	100,000		
Materials	30,000		
	$6,260,000		

The foregoing estimates are not conclusive upon the Contractor, provided that the total sum shall not exceed $6,260,000.

It shall be the obligation of the Contractor to mitigate for the purposes of this Paragraph all losses incurred, and the Government reserves the right to participate with the Contractor in settling the Contractor's obligations with its suppliers and the right to audit the Contractor's books and records before payment to the Contractor of any sum under this Paragraph.

ARTICLE XII. REPORTS, BOOKS AND RECORDS

The Contractor shall furnish the Government quarterly with copies of its current financial statements and such other reports as the Government may reasonably require concerning:

1. The progress and cost of the preparation of the Facilities;
2. The production and disposition of titanium and titanium products hereunder; and
3. The actual operating costs of the Facilities.

These reports shall be at least in such detail as is necessary to indicate the accumulation of the Contractor's cash return as defined in Article XI hereof. Reports as of the close of the Contractor's fiscal year shall be certified by an independent certified public accountant. The Contractor shall maintain separate books and records covering the operation of the Facilities.

ARTICLE XIII. PATENTS

A. The Contractor agrees to report to the Government, promptly and in reasonable written detail, each claim of patent infringement based on the performance of this Contract and asserted against it, or against any of its subcontractors if it has notice thereof.

B. In the event of litigation against the Government on account of any claim of infringement arising out of the performance of this Contract or out of the use of any supplies furnished or construction work performed hereunder, the Contractor agrees that it will furnish to the Government, upon request, all evidence and information in its possession pertaining to the defense of such litigation, and, except in the case of a claim of infringement of a patent or patent application of which any agency of the United States Government is a licensor or

custodian (excluding the custodianship created through the receipt of patent applications and the issuance of patents thereon in the normal manner), to the extent requested by Government, Contractor will at its own expense, aid in the defense of said litigation.

C. The Contractor agrees to indemnify the Government and its officers, agents and employees and nominees against liability, including costs and expenses, for infringement upon any Letters Patent of the United States (except Letters Patent issued upon an application which is now or may hereafter be, for reasons of national security, ordered by the Government to be kept secret or otherwise withheld from issue, and except in the case of a claim of infringement of a patent or patent application of which any agency of the United States Government is a licensor or custodian (excluding the custodianship created through the receipt of patent applications and the issuance of patents thereon in the normal manner)) arising out of the performance of this Contract or out of the use or disposal by or for the account of the Government of supplies furnished or work performed hereunder. The foregoing indemnity shall not apply unless the Contractor shall have been informed as soon as practicable by the Government of the suit or action alleging such infringement, and shall have been given an opportunity to present recommendations as to the defense thereof.

D. The Contractor agrees that, as to each new patentable invention made, conceived or acquired by it in the course of its performance hereunder in the Facilities constructed hereunder, the Government or its nominees may at any time on a non-exclusive royalty free basis, use said patents and/or inventions for production or construction under any Contract to the extent to which the United States Government is actually a purchasing party; and, in the event the Facilities hereunder are returned for operation by the Government, Contractor agrees that the rights hereinabove enumerated, together with patents and information owned or controlled by Contractor and necessary to the efficient and complete operation of said Facilities, shall be made available to the Government on a royalty free license basis. It is understood that control of patents, as used in the preceding sentence, does not include control by means of a non-royalty free license in the Contractor to use patents owned by others. Contractor further agrees that Contractor will, at Contractor's expense, promptly apply for Letters Patent for any and all improvements, discoveries and inventions deemed patentable and made in the course of or arising out of Contractor's performance hereunder. The Contractor agrees to have each of its technical and supervisory employees execute a contract satisfactory to the Government, whereunder such employee agrees to assign to the Contractor all rights to patents and patent applications as to each new patentable invention made, conceived or acquired by such employee through use of the Facilities covered under this Contract. Such patents and patent applications obtained by Contractor in this manner shall be subject to the foregoing conditions.

ARTICLE XIV. ADDRESSES

Unless otherwise specified:

(*a*) Notices by the Government to the Contractor provided for in this Contract shall be addressed to: Cramet Inc., 836 South Michigan Avenue, Chicago 5, Illinois.

(*b*) Notices by the Contractor to the Government shall be addressed to: Administrator, Defense Materials Procurement Agency, Washington 25, D. C. or such other address as either party for itself may specify to the other in writing.

ARTICE XV. COMPLIANCE APPLICABLE LAWS

In the performance of this Contract, Contractor shall comply with and give all stipulations and representations required by any applicable Federal, State, Municipal or local law, or Executive Order, or any applicable rules, orders, regulations or requirements of any governmental department or bureau, but nothing herein contained shall be considered as preventing Contractor from contesting in good faith the validity of such law, rule, order, regulation or requirement or any charge that Contractor has not complied therewith.

ARTICLE XVI. WALSH-HEALEY ACT

There are hereby incorporated by reference all representations and stipulations required by the Walsh-Healey Public Contracts Act, as amended (41 U. S. Code 35–45), and regulations issued thereunder by the Secretary of Labor, such

representations and stipulations being subject to all applicable rulings and interpretations of the Secretary of Labor which are now or may hereafter be in effect.

ARTICLE XVII. ANTIDISCRIMINATION

In connection with the performance of work under this Contract, the Contractor agrees not to discriminate against any employee or applicant for employment because of race, creed, color, or national origin; and further agrees to insert the foregoing provision in all subcontracts hereunder except subcontracts for standard commercial supplies or for raw materials.

ARTICLE XVII. CONTINGENT FEES

The Contractor warrants that no person or selling agency has been employed or retained to solicit or secure this Contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Contractor for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this Contract without liability or in its discretion to deduct from the Contract price or consideration the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE XIX. INTEREST OF MEMBER OF CONGRESS

No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this Contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this Contract if made with a corporation for its general benefit.

ARTICLE XX. ACCESS TO BOOKS AND RECORDS

The Contractor agrees that the Government or any of its duly authorized representatives shall, while the Contract is in effect, and for a period of three (3) years thereafter, have access to and the right to examine any pertinent books, documents, papers and records of the Contractor involving transactions related to this Contract.

The Contractor further agrees to include the following provision, with appropriate insertions in all its subcontracts (herein defined as any agreement with another party providing for construction, improvements, or other work called for by this Contract, whether or not that purpose is so specified in the agreement) hereunder:

"(*Name of Subcontractor*) agrees that the Government or any of its duly authorized representatives shall, until the expiration of three years after final payment under Prime Contract (*Contract Symbol and Number*) between the United States of America and Cramet Inc., have access to and the right to examine any pertinent books, documents, papers and records of (*Name of Subcontractor*) involving transactions related to this Contract."

ARTICLE XXI. ASSIGNMENT

The Contractor shall not, without the prior written consent of the Government, sell, assign, or pledge this Contract or any of its rights, powers, privileges, duties or obligations thereunder; provided, however, that Crane Co., Chicago, Illinois, shall at its written election and prompt notice thereof to the Government, be substituted as the Contractor hereunder (by agreement between Crane Co. and the original Contractor, or by operation of law in the case of liquidation, merger or consolidation) with all rights, liabilities and obligations of the original Contractor, at any time without such consent of the Government; and further provided that any moneys due or to become due under this Contract, but not including any advances made or to be made hereunder, may be assigned by the Contractor to a bank, trust company or other financing institution, including any Federal lending agency, pursuant to and in accordance with the Assignment of Claims Act of 1940, as amended (31 U. S. C. 203, 41 U. S. C. 15).

All rights, powers, privileges, duties or obligations under this Contract shall inure to any successor or successors of Defense Materials Procurement Agency or any branch or agency of the Government to which the Defense Materials Procurement Agency shall hereafter delegate or assign its authority to act for the Government hereunder.

ARTICLE XXII. FORCE MAJEURE

If the performance of any part of this Contract by either the Contractor or the Government is prevented, hindered or delayed by reason of any cause or causes beyond the respective control of the Contractor or the Government, and which cannot be overcome by due diligence, then the Contractor or the Government, as the case may be, shall be excused from such performance during the continuance of any such happenings or events. To become operative, the Contractor or Government, as the case may be, shall give to the other, within ten (10) days after the occurrence of such happenings or events, written notice thereof, together with a statement setting forth the facts in evidence, and, upon the conclusion of such happenings or events, shall notify the other in writing of such termination within ten (10) days. The effect of such delays shall be to extend the periods referred to in Articles I, II, VI, X and XI to the extent of such delays.

ARTICLE XXIII. DEFAULT

Notwithstanding any other provision of this Contract, the Government may, by notice in writing to the Contractor, cancel this Contract or any part thereof at any time, without payment by the Government of damages or penalty of any kind for such cancellation, in the event (a) a receiver, liquidator, or trustee is appointed for the Contractor or its property, or the Contractor makes an assignment for the benefit of creditors, or the Contractor becomes insolvent, or a petition is filed by or against the Contractor pursuant to any of the provisions of the United States Bankruptcy Act, as amended, for the purpose of adjudicating the Contractor a bankrupt, or for the reorganization of the Contractor, or for the purpose of effecting a composition or rearrangement with the Contactor's creditors, and such receiver, liquidator, or trustee is not discharged or any such petition filed against the Contractor is not dismissed within sixty (60) days, (b) of the liquidation or dissolution of the Contractor, whether voluntary or involuntary, (c) of the determination by the Government that the Contractor obtained this Contract for the purpose of speculation, (d) of default by the Contractor in the performance of any of the terms, conditions or covenants of this Contract or any amendment or supplement thereto, and of failure by the Contractor to cure such default within sixty (60) days after written notice thereof is given by the Government. In the event this Contract is cancelled by the Government pursuant to the terms of this Article, the balance of any advance payments made by the Government hereunder, including accrued interest, shall be immediately due and payable by the Contractor to the Government.

ARTICLE XXIV. NON-WAIVER

The failure of either the Contractor or the Government to insist in any one or more instances upon the performance of any of the terms, covenants or conditions of this Contract, shall not be construed as a waiver or relinquishment of the future performance of any such term, covenant or condition by the other party hereto, but the obligation of such other party with respect to such future performance shall continue in full force and effect.

ARTICLE XXV. MODIFICATIONS

No oral statement of any person shall modify or otherwise affect the terms, conditions or specifications of this Contract.

ARTICLE XXVI. MANAGEMENT, INDEMNIFICATION, GUARANTY AND CONTROL

The Contractor shall deliver to the Government promptly and prior to the payment of any funds to the Contractor by the Government the following documents in form and substance satisfactory to the Government (which shall recite that they are made as an inducement to the Government to enter into this Contract and in consideration of the making of this Contract by the Government) :

1. An agreement of Crane Co., Chicago, Illinois, that it will furnish to the Contractor whatever management and supervisory personnel may be needed by the Contractor efficiently to carry on the operations required under this Contract and that it will supervise the management of said operations.

2. An agreement by Crane Co., Chicago, Illinois, under which it agrees that, as long as any of the advance or advances made by the Government to the Contractor under this Contract and interest thereon are unpaid, (a) it will indemnify the Government for any loss incurred by it as a result of the use of Government funds by the Contractor in violation of the terms of this Contract, and (b) it will not sell, pledge or otherwise hypothecate its interest, or any part thereof, in the Contractor as of the date of execution of this Contract.

ARTICLE XXVII. USE OF RAW MATERIALS

The Contractor hereby agrees that the Facilities to be constructed as provided for in this Contract, will be capable of using, in the production of titanium sponge, raw materials presently readily available on the North American Continent; it being understood, however, that the Contractor is not precluded from the use of raw materials from other sources.

ARTICLE XXVIII. CANCELLATION

Notwithstanding any other provision hereof, this Contract shall automatically terminate as to any portion of the Contract remaining uncompleted on June 30, 1962; provided, however, that the Contractor's obligation with respect to repayment of any advances made hereunder and accrued interest thereon and with respect to storage and shipment of the titanium sponge shall survive the termination of this Contract.

IN WITNESS WHEREOF, the parties hereto have caused this document to be duly executed on this 31st day of July, 1953.

UNITED STATES OF AMERICA,
Acting by and through Defense
Materials Procurement Agency.
IRVING GUMBEL,
Acting Deputy Administrator.
CRAMET, *Inc.*,
By /s/ H. H. BUNCHMAN,
Title *Vice President.*

Attest:

By /s/ K. Z. KARR, *Secretary.*

[CORPORATE SEAL]

AMENDMENT NO. 1
TO
CONTRACT NO. DMP–75
BETWEEN
UNITED STATES OF AMERICA
AND
CRAMET INC.

THIS AMENDMENT, entered into between the United States of America, hereinafter called the "Government," acting through the Administrator of General Services, his successors, assigns and duly authorized representatives, (pursuant to the authority contained in the Defense Production Act of 1950, as amended, and Executive Order No. 10480) and Cramet Inc., a corporation organized and existing under the laws of the State of Delaware, hereinafter referred to as the "Contractor,"

WITNESSETH

Whereas, the Government, acting through the Defense Materials Procurement Agency, on July 31, 1953, entered into Contract No. DMP–75, hereinafter called the "Contract," with the Contractor covering production of titanium sponge to be produced at Contractor's facilities in or near Nashville, Tennessee; and

Whereas, Contractor desires to establish its facilities in or near Chattanooga, Tennessee; and

Whereas, by virtue of the aforesaid Executive Order No. 10480, Defense Materials Procurement Agency has been abolished, and certain of its functions assigned or delegated to the Administrator of General Services;

Now, therefore, it is hereby mutually agreed by and between the parties hereto that the Contract shall be and it is hereby amended as follows:

First: That the words "in or near Nashville, Tennessee" where they appear in Article I thereof be deleted and the words "in or near Chattanooga, Tennessee" be substituted therefor.

Second: That the words "at or near Nashville, Tennessee" where they appear in Article VIII thereof be deleted and the words "at or near Chattanooga, Tennessee" be substituted therefor.

All other terms and conditions of the Contract not otherwise inconsistent herewith shall remain in full force and effect.

IN WITNESS WHEREOF, the parties hereto have caused this Amendment to be duly executed this 2d day of September, 1953.

UNITED STATES OF AMERICA,
By E. F. MANSURE,
Administrator of General Services.

CRAMET, INC.,
H. H. BUNCHMAN,
Vice President.

Attest:

K. Z. KARR, *Secretary.*

[CORPORATE SEAL]

APPENDIX A

SPONGE SAMPLING AND ANALYTICAL METHODS

The supplier shall certify that all material scheduled for delivery meets the sponge specifications aforementioned and further analysis shall be at the option of the Government. Ninety-five percent (95%) of the weight of each lot shall pass a ½" screen and not to exceed 1.5 percent shall pass a 20-mesh sieve. The following procedures for sampling and analysis shall be employed by the Government. As further commercial experience is developed, these procedures may be modified by mutual agreement of the contractor and the Government.

Packaging.—All material shall be packaged in a moisture-resistant fiber container such as "Lever-Pack"—Style M–3207, Size 8X or 10X, or equivalent, and all containers in a given lot shall be of the same nominal size and shape.

A. *Preliminary Sampling.*

A lot shall consist of approximately 20,400 pounds composed of four blends of 5,100 pounds each, packed in 17 moisture-resistant fiber drums. Three random drums will be sampled from each 5,100-pound blend scheduled for delivery. Twelve drums will be sampled to represent a lot. Samples from the twelve drums will be blended for one analysis as follows:

(1) Each drum containing approximately 300 pounds will be sampled by passing the sponge through a 1" riffle until a sample of approximately 12 pounds is obtained from each drum.

(2) The 12-pound sample from each of the twelve drums shall be placed in a 50-gallon drum. Similar samples from the eleven additional drums shall be combined in the drum which shall not be more than half filled with the combined sample (weighing about 144 pounds).

(3) The composite particle size of the sponge contained in the drum shall be reduced, preferably to —⅜". The size-reduced sponge is returned to the drum which is securely closed with a lid and rolled back and forth across the floor for at least ten rolls, about ten feet per roll to insure thorough mixing. This blended sample is representative of the quality of 68 drums or about 20,400 pounds of sponge.

(4) After blending, the sponge is passed through a ½" riffle until a representative sample weighing about 9 pounds (approximately filling a one-gallon can), is obtained.

(5) The unused balance of the sample will be returned to the shipment for delivery.

B. *Sample Preparation*

(1) *Analytical Sample.*—(*a*) The gallon sample is passed through a ½" riffle to obtain two samples each weighing approximately four pounds. From one of the four-pound samples, three one-half pound samples are obtained by riffling; the remaining two and one-half pounds is returned to the gallon can. The half pound samples are compacted and drilled to yield analytical drillings as described in section C.

(2) *Hardness Determination Sample.*—(*a*) The remaining four-pound sample is separated into four equal portions using a ½" riffle. One of the quarters is returned to the gallon can. Each of the remaining quarters is placed in a clean, dry, screw-top glass jar of adequate size. These quarters serve as hardness determination samples. One quarter (approximately one pound) is for the contractor, one for the Government, and one for umpire use in the event of Arbitration. The latter two quarters shall be retained by the Government.

(*b*) For hardness determination, the one-pound sample is further divided, using the ½" riffle, into four equal portions each weighing about 100 grams. Two of the samples are melted for hardness determination, the remaining quarters are returned to the jar for additional tests if necessary.

C. *Compressing and Drilling*

(1) Set up the 2" dies, shown in the attached sketch, on the stand in preparation for making compresses; charge one of the one-half pound samples to the die.

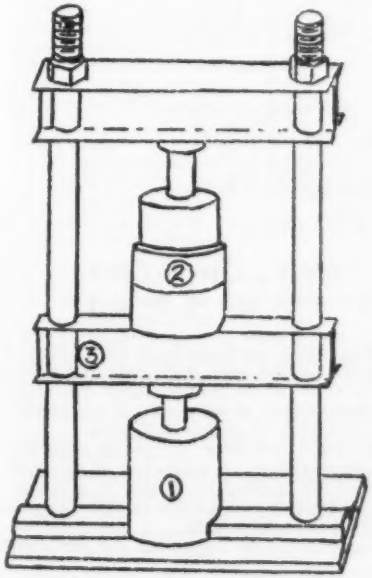
(2) Compress the sample in the press, as shown on the sketch, to 100,000 lbs. total pressure. Repeat procedures (1) and (2) with each of the remaining half pound samples.

(3) Clamp one of the dies filled with the compress in a small vise, placing a clean sheet of smooth paper between the die and the vise jaws. The paper should be large enough to catch all of the drillings. Drill one hole with 1 7/16" drill while the compress remains in the die. Place the drillings in a clean one-half pint jar with screw top. Each compact will yield about 125 g. of drillings.

(4) Repeat the drilling on the other compresses and place all the drillings in the sample jar. The drillings should amount to approximately 375 grams.

(5) Spread the drillings on a clean sheet of paper. Run a magnet thoroughly over the drillings to remove magnetic tramp iron particles accumulated during sample preparation.

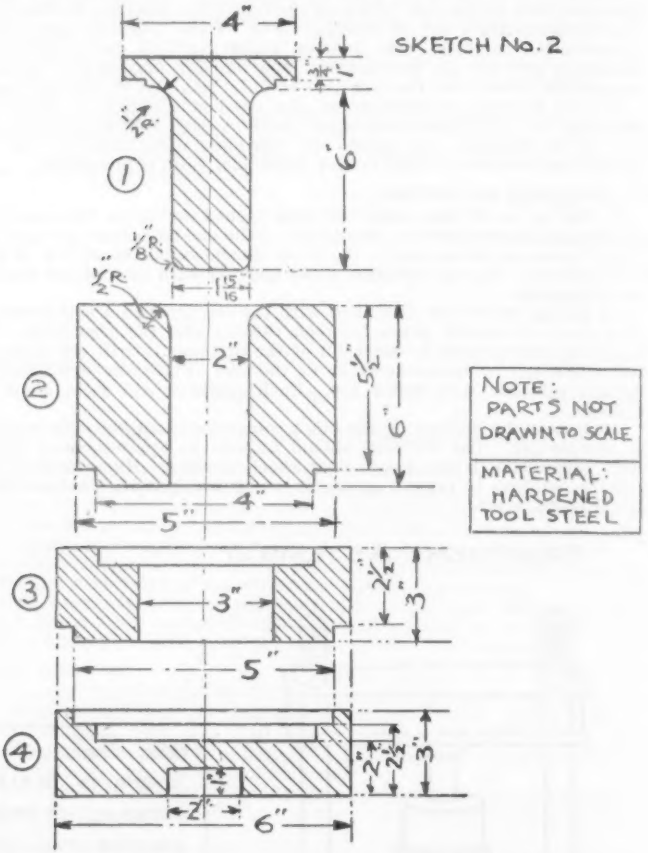
EQUIPMENT ASSEMBLY



NOTE: PARTS NOT DRAWN TO SCALE
MATERIAL: OF FRAME COLUMNS - TOOL STEEL
1. 50 TON Hydraulic JACK
2. DIE ASSEMBLY (DISCHARGING COMPRESS)
3. FRAMEWORK

SKETCH No. 1

DIES USED IN MAKING COMPRESSES



MAKING COMPRESS ~ SET UP 4-2-1
DISCHARGING COMPRESS - SET UP 4-3-2-1

(6) The drillings are separated into three portions in a ½" riffle. If a 3-way riffle is not available a 2-way riffle can be used with repeated riffling of one quarter followed by recombination with the remaining three quarters. In this case one quarter of the twice riffled sample is rejected. A suggested ½" riffle is A. H. Thomas Catalog #8860, 6"×6" with chutes ½" wide.

This system provides three samples of not less than 120 grams each for the contractor, the Government, and umpire analysis. A single set of analyses requires about 40 grams. The Government will submit its sample to a laboratory of its choice for analysis and will seal and retain the umpire sample for possible use in case of differences leading to rejection of shipments.

(7) The three drilled compresses are returned to the gallon can and retained by Du Pont.

NOTE (1).—Sample drums, cans and jars, papers, drill vise and drill must be clean and free from grease, moisture and other foreign matter. It is necessary to avoid excessive handling of the compresses before drilling, using

clean gloves to handle or to position the compresses in the drill vise. Moist hands may result in sufficient surface contamination to make subsequent analyses erroneous. All drillings should be dried at 110° C. for 2 hours before analysis to minimize surface moisture

D. *Analytical methods and hardness determination*

Analytical methods for titanium, iron, nitrogen and chloride, and methods for hardness determination follow. Samples from the drilling operation will be used for analyses only. Analytical samples will be obtained by riffling of the drillings in the laboratory prior to weighing. Riffle should be similar to A. H. Thomas Catalog #8860, 6"×6" with chutes ½" wide. Hardness determination samples shall be melted as sponge particles, not drillings.

APPROVED ANALYTICAL METHOD, TITANIUM METAL SPONGE

DETERMINATION OF TITANIUM

Application.—To the determination of the titanium content of titanium metal in the form of sponge.

Outline.—The titanium metal is converted to soluble form by fusion with potassium bisulphate. It is then taken up in dilute hydrochloric acid and completely reduced to the trivalent state by a two-stage process employing metallic zinc. The reduced solution, held under an atmosphere of carbon dioxide, is titrated with standardized ferric alum using thiocyanate as an inside indicator from which the titanium content of the sample is computed.

Equipment.—

Erlenmeyer flasks, 300 ml., pyrex or vycor
Tuttle flask covers
Potassium bisulphate, fused, pure
Sulphuric acid, concentrated
Blast burners
Hydrochloric acid, 50 percent by volume
Florence flask, 1000 ml.
Cylinder of CO_2 with regulating valve
Amalgamated zinc shot
Amalgamated 20 mesh zinc
Modified Jones reductor
Flow meter for measuring CO_2
Glass wool
Flask tongs
Hydrochloric acid, 10 percent by volume
Standard 0.1N ferric alum solution in burette
Potassium thiocyanate or sodium thiocyanate solution, 400 g/l.

Procedure.—1. Accurately weigh about 0.2 gram of the sample and transfer to a 300 ml. pyrex of vycor Erlenmeyer flask which contains 15 to 25 grams of potassium bisulphate and 10 drops of concentrated sulphuric acid.

2. Place a Tuttle cover in the neck of the flask and heat over the full flame of a blast burner until the bisulphate has fused and no undecomposed sample remains. This operation will require about 30 minutes. During the fusion, pick up the flask frequently with a pair of tongs and whirl to mix the contents.

3. Remove the flask from the flame with the tongs and by means of a rotary motion cause the melt to solidify in a uniform layer on the side and bottom of the flask.

4. When the contents of the flask have cooled, add 100 ml. of 50 percent (by volume) hydrochloric acid and dissolve the fusion by careful heating. Avoid violent boiling.

5. Add 60–80 grams of amalgamated zinc shot.

6. Place on a hot plate and bring to a boil. Boil gently for 10 minutes.

7. For the initial sample in a series, prepare the reductor assembly by first drawing the liquid level in the reductor reservoir to about ¼ to ½ inch above the top of the zinc column. Set the 1 liter Florence flask in place in the reductor assembly. Connect the carbon dioxide supply, turn it on, regulate the flow to 1 to 2 liters per minute CO_2 and allow it to run for two minutes to flush all the air out of the flask before it is used.

8. Drain the acid remaining in the reductor down to the level of the top of the zinc column.

9. Pour the reduced solution from the Erlenmeyer flask into the top of the reductor and add a preliminary rinse of the zinc shot with not more than 15 ml. of 10 percent hydrochloric acid which has been stirred into the zinc.

10. Open the stopcock and allow the solution to pass through the reductor and into the receiving flask.

NOTE 1.—The time required for the acid solution from the flask to pass through the reductor should be between 3 and 5 minutes. This rate may increase considerably in the succeeding washing operation. It is also important that solutions flow through the reductor by gravity and are not forced through by means of vacuum or pressure. Furthermore, the solution after flask digestion and after the small preliminary rinse mentioned in Step II should never be diluted with water or weak acid in order to make it flow faster through the reductor. Dilution at this point increases the normal reoxidation due to the transfer from the flask to reductor and decreases the efficiency of the zinc in the reductor.

11. When the liquid level in the reductor has dropped *almost to the top of the zinc column*, close to the stopcock, rinse the sides of the reductor reservoir and stirring rod with a few ml. of 10 percent hydrochloric acid from a wash bottle and drain the rinsings to the top of the zinc column.

NOTE 2.—It is imperative that the zinc column in the reductor be not exposed to air at any time. The level of the liquid must never be drawn below the top of the column.

12. Rinse the zinc shot in the flask with not less than three successive 75 to 100 ml. portions of 10 percent hydrochloric acid and pass them through the reductor, permitting each rinse to be drawn down nearly to the top of the zinc column before adding the succeeding rinse.

13. Rinse the sides of the reductor reservoir and the stirring rod again as in Step 11.

14. Finally rinse the reductor with an additional portion of 10 percent hydrochloric acid. Allow this to drain down to about ¼ to ½ inch above the top of the zinc column. The total volume of the reduced solution in the receiving flask should now be 500 to 750 ml.

15. Remove the receiving flask from the reductor. If another sample is to follow immediately, place another Florence flask in the reductor assembly in order to allow the CO_2 to displace the air in preparation for the next sample. If another sample is not to follow at once, turn off the CO_2 and fill the reductor reservoir with 10 percent hydrochloric acid. (See note 4 which follows after Step 18 regarding care of the reductor.)

16. Quickly add 20 ml. of 400 g/l NaCNS or KCNS solution to the flask containing the reduced solution. Do not shake the flask to hasten mixing of the indicator solution.

17. Place the flask under a burette filled with standard 0.1N ferric alum solution and proceed immediately with the titration, allowing about 90 percent of the estimated requirement of ferric alum to enter the flask. Then, shake the flask gently until the solution is decolorized. Continue the titration, shaking only enough to decolorize the solution until the permanent straw-colored end point is reached, at which time the violence of the shaking may be increased to insure the end point. Before making the final burette reading, wash down the neck of the flask with a little distilled water from a wash bottle to insure complete reaction between the reduced titanium and ferric alum.

NOTE 3.—The mechanics of carrying out the titration has been outlined in considerable detail in the above step, as an aid to uniform and precision work. Unnecessary shaking must be avoided in order to prevent loss of CO_2 from the flask. In routine work the approximate titration will be known; therefore, most of the ferric alum may be added before any shaking is done. In the case of unknowns, it is preferable to carry out duplicate titrations, the first to be run as a pilot and the second to be done more carefully. The result of the second will be used for reporting. Some chemists will prefer to carry out the titration by adding essentially all of the ferric alum with little or no shaking before adding the sulphocyanate indicator. This is permissible.

18. Calculation: $$\frac{\text{Ml. ferric alum} \times \text{factor}^* \times 100}{\text{Wt. of sample taken}} = \text{percent Ti}$$

*Factor in this case is gms. Ti equivalent to 1.0 ml. of standard ferric alum.

Or, if preferred: $\frac{\text{Ml. ferric alum} \times N \times 0.0479 \times 100}{\text{Wt. of sample taken}} = \text{percent Ti}$

NOTE 4.—It is recommended that the Jones reductor, when idle, should be left with 10 percent acid covering the zinc. This is preferable to replacement of the acid with water, even for periods of a week or more.

NOTE 5.—*Standards*: As an aid to precision work, it is recommended that a standard sample of known TiO_2 content (Standard TiO_2 sample No. 154 may be obtained from the Bureau of Stds.) be carried through the procedure parallel with each sample or series of samples.

NOTE 6.—Recommended procedures follow for—(a) Preparation and Standardization of Ferric Alum Solution; (b) Amalgamation of Zinc Shot for Flask Reduction; (c) Amalgamation of 20 Mesh Zinc for Flask Reduction.

(*a*) *Preparation and standardization of 0.1N ferric alum solution*

Application.—This method applies to standard ferric alum solution of approximately 0.1N as used in the determination of titanium content of titanium metal.

Reagents.—

Ferric ammonium sulphate (ferric alum)
$Fe_2(SO_4)_3(NH_4)_2SO_4 24H_2O$ C. P.
Sulphuric acid, conc. C. P.
Ammonium Sulphate, C. P. Cryst.
Potassium permanganate, dilute solution
Standard TiO_2 sample
Jones reductor and other equipment for determination of TiO_2 according to Manual Code TP–27.1 or revisions thereof.

Procedure.—0.1N Ferric Alum Soln.:

1. As this solution is usually prepared in a volume of 18 liters in a 5 gallon bottle, the quantities given below are for a final volume of 18 liters of the solution.
2. Dissolve 870 to 875 grams of C. P. ferric ammonium sulphate (ferric alum) in 2 to 3 liters of distilled water with agitation.
3. Add 500 ml. of C. P. concentrated sulphuric acid and mix thoroughly.

NOTE.—The quantities of material required for 1 liter of 0.1N ferric alum are: 48.5 grams ferric alum, 28 ml. H_2SO_4 and 100 to 150 ml. distilled water, to be diluted to one liter with distilled water after solution of the salt is complete.

4. Filter through a #5 Whatman filter paper.
5. Transfer to the final container and dilute to volume with room temperature distilled water.
6. Add dilute $KMnO_4$ solution drop by drop and with mixing until a permanent faint pink coloration is discernable in the solution.
7. Mix completely by rolling for one hour or by bubbling clean (filtered) air through the solution for about sixteen hours (usually overnight).
8. Allow the solution to stand relatively undisturbed for at least 24 hours before using to allow for temperature equilibrium, air bubbles to escape, etc.

Procedure.—Standardization:

9. Dry a portion of the std. TiO_2 in a weighing bottle in an oven at 140° C. for not less than one hour.
10. Cover the weighing bottle, remove from the oven place in a desiccator and permit it to cool. Retain the dried portion of the sample in the desiccator, except when weighing out portions, until it is depleted. The drying may be repeated at intervals as necessary.
11. Accurately weigh approximately .30 gram portions of the dried standard TiO_2.
12. Proceed according to Steps 1 through 18 of preceding method. "Determination of Titanium."
13. $\frac{\text{Wt. standard sample} \times \text{percent Ti}}{\text{Ml. ferric alum} \times 100}$ of sample=Ti factor*

(*b*) *Amalgamation of zinc shot for the flask reduction*

Apparatus and reagents.—Zinc shot (reagent grade), hydrochloric acid, concentrated, c. p., mercuric chloride, wooden paddle.

Procedure.—1. Weight 1000 grams of zinc shot into a one or two liter beaker or jar.

*Item 18 in foregoing method (Determination of Titanium).

2. Wash the zinc twice with tap water, and then cover with water to ½" above the top of the zinc.

3. Prepare an amalgam solution by weighing 24 grams of mercuric chloride into a 400 ml. beaker and dissolving completely with 220 ml. of concentrated, c. p. hydrochloric acid.

4. Add the amalgam solution to the zinc with vigorous agitation with a wooden paddle. Continue the agitation for one to two minutes.

5. Pour off the amalgam solution and wash the zinc by decantation with tap water no less than 12 times, or, if preferred, transfer the zinc to a funnel and allow tap water to flow over it for ½ hour.

6. Finally wash the zinc twice with distilled water, and store it in a covered beaker or jar, and keep the zinc covered with distilled water until used.

NOTES.—1. If it is desired to prepare other quantities of amalgamated zinc shot than specified above, multiples of the above quantities may be used.

2. Safety precautions: During the amalgamation, certain safety precautions must be taken. Some heat or reaction is given off, and there is considerable evolution of hydrogen. Acid goggles, rubber gloves and a rubber apron should be worn and the process should be carried out in a hood with running water available, if possible. Precaution must also be taken to insure that nearby workers are not exposed to these hazards.

(c) *Amalgamation of 20 mesh zinc and method of charging Jones reductor*

Apparatus and Reagents.—20 mesh zinc (Reagent grade), concentrated, c. p., hydrochloric acid, mercuric chloride, modified Jones reductor.

Procedure.—Refer to Figures 1 and 2 (appended).

1. Weigh 300 grams of 20 mesh zinc into a one-liter Florence flask.

2. Wash the zinc twice with tap water, and then cover with water to ½" above top of zinc.

3. Prepare amalgam solution by weighing 14 g. of mercuric chloride into a 400 ml. beaker and dissolving completely with 122 ml. of concentrated, c. p., hydrochloric acid.

4. Add the amalgam solution to the zinc in six portions with a vigorous 15 seconds up and down shaking after each addition. After the last addition, the shaking is continued for 1½ minutes.

5. Pour off the amalgam solution and wash with tap water no less than 12 times, ½ minute being sufficient for each wash with fresh water.

6. To the reductor, which has been previously prepared with a mat of glass wool and filled with water, immediately add the washed zinc and let it settle down into position in the reductor column. (Note 1)

7. Allow the charged reductor to stand undisturbed for at least two hours (preferably longer) before being used. This allows the zinc to "set" in position and lengthens the useful life of the reductor.

8. Just before using the reductor, wash it with three 300 c. c. portions of hot 15 percent HCl.

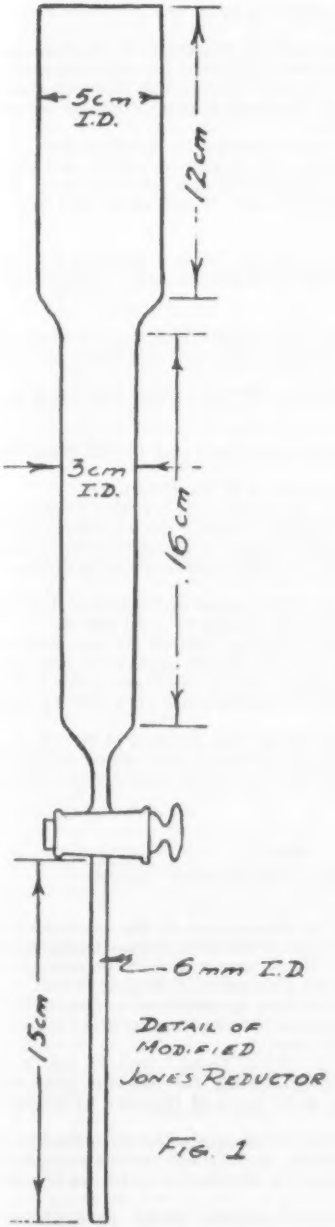
9. Whenever finished with a reductor, leave it standing with the zinc covered with 10 percent hydrochloric acid. A reductor must never be allowed to dry.

NOTES.—1. This quantity of amalgamated zinc is about right to give a zinc column of 13 cm. with the present supply of reductors. Since the I. D. of the reductors varies slightly from time to time, it is necessary to vary the quantity of amalgamated zinc to insure the 13 cm. column.

2. After continued use, the rate of flow through the reductor will decrease considerably. When this occurs, the zinc column should be discarded and the reductor freshly charged.

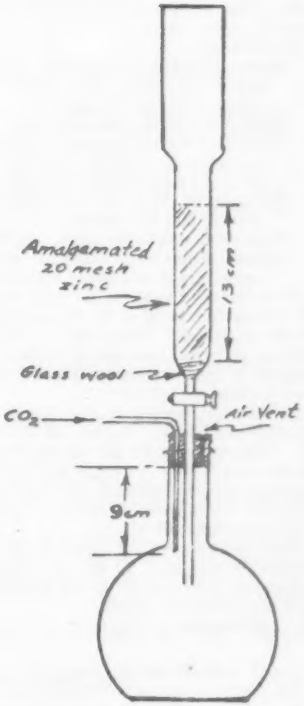
3. A standard sample of known TiO_2 content is included with each sample or series of samples, and if the result on the known fails to check the known value of the standard, the zinc column should be discarded, the reductor freshly charged and the determination repeated.

4. Safety Precaution: During the amalgamation certain safety precautions must be taken. Some heat of reaction is given off and there is considerable evolution of hydrogen. Acid goggles, rubber gloves and a rubber apron should be worn, and the process should be carried out in a hood with running water available, if possible. Precaution must also be taken to insure that nearby workers are not exposed to these hazards.



DETAIL OF MODIFIED JONES REDUCTOR

FIG. 1



ASSEMBLY FOR "FLASK-REDUCTOR FILTRATION

FIG. 2

DETERMINATION OF NITROGEN

Application.—To the determination of the nitrogen content of titanium metal in the sponge form. As written, the method is suitable for determination of nitrogen up to 2 percent of the sample weight. Should the nitrogen content exceed 2 percent, additional distillation of the sample is required as provided for in a note which appears in the procedure.

This method does not apply to nitrogen determination in ingot samples.

Outline.—The sample after decomposition with sulphuric acid is neutralized with caustic. The nitrogen is removed by distillation and collected under boric acid. The distillate is titrated with standard 0.007 N sulphuric acid and the nitrogen calculated.

Equipment.—

Micro Kjeldahl apparatus, supplied by Scientific Glass Apparatus Co., catalog No. M–3065 and provide with a 150 ml. digestion flask. Other similar apparatus may be used.

Sulphuric acid, concentrated.

Prepared NaOH solution. Dissolve 365 grams NaOH in 1 liter of water, add 1.0 gram de Vardos alloy, boil for one-half hour, cool and dilute to 1 liter. Store in a tightly stoppered bottle.

Boric acid, 0.17 percent solution. Prepare by dissolving 0.85 gram boric acid in 500 ml. water.

Standard sulphuric acid. 0.007 N.

Mixed indicator. Dissolve 0.0167 gram methyl red and 0.0833 gram brom cresol green in 100 ml. ethyl alcohol.

Procedure.—Preparation and Standardization of H_2SO_4 Solution:

1. Transfer, with a T. D. pipette 2.0 ml. of concentrated H_2SO_4 to a 1 liter volumetric flask. Make up to mark with distilled water. Dilute 100 ml. of this solution to 1 liter in a second volumetric flask and mix. This finally diluted H_2SO_4 solution is approximately 0.007 N and 1.0 ml. is equivalent to about 0.0001 gm. N. Standardize as follows:

2. Dissolve exactly 0.3820 gm. of C. P. NH4Cl in water and dilute to 1 liter in a volumetric flask. 1.0 ml. of this solution is equivalent to 0.001 gm. N.

3. Take exactly 10 ml. of the above NH4Cl solution, add 20 ml. water and 5.0 ml. of conc H_2SO_4. Cool, transfer to the micro distillation apparatus, add 30 ml. prepared NaOH solution and distill, collecting 25 ml. of distillate under 10.0 ml. of 0.17% boric acid solution. Titrate with the H_2SO_4 solution (Step 1) which is to be standardized.

Determine a reagent blank by distilling 5.0 ml. of concentrated H_2SO_4, 30 ml. of distilled water and 30 ml. of prepared NaOH solution in the micro distillation apparatus catching 25 ml. of distillate under 10.0 ml. of 17% boric acid. Titrate with the H_2SO_4 solution.

5. Calculation of Factor:

$$\text{N Factor} = \frac{0.001}{\text{ml. titration (step 3)} - \text{blank titration (step 4)}}$$

Procedure.—Determination of Nitrogen:

NOTE.—If nitrogen and iron are to be determined on the same 10 gram sample portion as noted in method, "Titanium Metal Sponge—Determination of Iron," proceed with Step 6a below. If nitrogen only is to be determined, using a fresh 1 gm. portion of the sample, proceed with Step 6b below.

6a. Transfer to the micro distillation apparatus, by means of a pipette, 50 ml. of solution of decomposed sponge sample prepared according to Steps 5 to 8 of "Titanium Metal Sponge—Determination of Iron."

6b. Dissolve 1 gram of sample in 5.0 ml. H_2SO_4 (conc.) and 35 ml. water. Heat until solution is complete and continue heating for one-half hour after evolution of hydrogen has ceased. Dilute to 35 ml. and transfer to the micro distillation apparatus.

7. Add 30 ml. of prepared NaOH solution to the sample solution in the distillation apparatus, to neutralize the acid. Distill, and collect the distillate under 10 ml. of 17% boric acid solution. Continue the distillation until not less than 25 ml. of distillate has collected.

NOTE.—For samples of normal nitrogen content, 25 ml. of distillate is sufficient to contain all the nitrogen. If the nitrogen should exceed 2 percent of the sample, remove the distillate and conduct a second distillation of the

remainder of the solution in the apparatus, catching the distillate under a fresh portion of boric acid solution. If nitrogen is found in this second distillate, the quantity should be added to that found in the final distillate.

8. Add 8 drops of mixed indicator solution to the distillate and titrate with the standard H_2SO_4 solution until the color changes from blue to red.

9. Determine a reagent blank, for each test or group of tests conducted at any one time, according to Step 4 of this method.

10. Calculation:

$$\%N = \frac{(\text{Ml. std. } H_2SO_4 - \text{blank}) \times \text{Factor} \times 100}{\text{Wt. sample portion taken}}$$

DETERMINATION OF IRON

Application.—To the determination of the iron content of titanium metal in the sponge form.

Outline.—This method is an adaptation to the specific purpose of a conventional colorimetric procedure for the determination of iron in titanium metal sponge. The sample is dissolved in sulphuric acid.

The iron is oxidized with permanganate and the subsequent addition of potassium thiocyanate imparts a characteristic color with the ferric iron, the intensity of which is proportional to the iron content. The color intensity is then graded against a suitable iron standard.

Equipment.—

Flasks, volumetric, 250, 500, and 1000 ml.
Pipettes, 5, 10, 25 and 50 ml.
Beakers, Pyrex, 800 ml.
Beakers, Pyrex, 250 ml., or 200 ml. tall form
Nessler tubes, 100 ml., matched
Ferrous ammonium sulphate, $FESO_4(NH_4)_2SO_4$–$6H_2O$, C. P. crystals for preparation of standard Fe solution.
Sulphuric acid, H_2SO_4, conc. C. P.
Potassium permanganate, KMNO4, standardized N/10 solution
Sulphuric acid, H_2SO_4 6N, C. P.
Potassium thiocyanate, KSCN, 250 gm./1 solution

Procedure.—1. Preparation of Standard Iron Solution:

1. Dissolve exactly 0.7023 gm. $FeSO_4(NH_4)_2SO_4$–$6H_2O$ in 200 ml. distilled water and 20 ml. conc. H_2SO_4.

2. Titrate the above solution with standard N/10$KMnO_4$. (The purpose of this titration is two-fold, first, to oxidize the iron to the ferric condition, second, to check the iron content). Calculate the iron content of the solution. If the calculated iron (Fe) content is 0.1 gm ±1.0 percent, the solution is satisfactory for dilution as follows:

3. Transfer the titrated solution to a 1000 ml. volumetric flask. Dilute to mark with distilled water and mix.

4. Transfer a 50 ml. aliquot of the solution to a 500 ml. volumetric flask, add 10 ml. conc. H_2SO_4, cool to room temperature and dilute to the mark with distilled water. 1 ml. of this finally diluted solution will contain 0.00001 gm. Fe.

Procedure.—II. Determination of Iron:

5. Riffle the sample to obtain an 8 to 12 gm. portion. Weigh this portion accurately on an analytical balance and transfer to a 600 Ml. beaker.

6. Add 300 ml. of 6N sulphuric acid and boil gently until solution is complete.

7. Transfer the solution to a 500 ml. volumetric flask.

8. Cool the contents of the flask to room temperature, dilute to the mark with distilled water and mix.

NOTE A.—If nitrogen is to be determined on the sponge sample, decomposed as above, 50 ml. of the solution as diluted in Step 8, may be taken. Refer to "Titanium Metal Sponge—Determination of Nitrogen."

9. Pipette 25 ml. of the solution in the flask and transfer to a second 500 ml. volumetric flask. Add 17.5 ml. of concentrated sulphuric acid (to maintain acid concentration), cool to room temperature, dilute to mark and mix.

10. Transfer 5 to 25 ml. of the solution, depending on the iron content, to a 250 ml. beaker. (See Note B which follows).

NOTE B.—The amount of sample to be taken for the final color matching is to be such that not less than 1.0 ml. or more than 4.0 ml. of the standard Fe solution are required. Adjustments in the aliquot to be taken in Step 10

may be made so as to care for this. In certain cases it may be necessary to also vary the aliquot taken in Step 9 in order that the standard Fe additions fall within the required limits.

11. Add 50 ml. of distilled water and N/10$KMnO_4$ in excess to oxidize the iron.

12. Prepare a blank solution using 50 ml. of water and 0.2 ml. conc. H_2SO_4 for each 5 ml. aliquot of solution taken in Step 10 and pink with N/10$KMnO_4$.

13. Add exactly 5 ml. of KSCN solution from a burette to each sample and blank portion, transfer each portion to 100 ml. Nessler tubes and mix.

14. Add measured increments of the standard iron solution (1ml.=0.00001 gm. Fe) to the blank to reach a color match with the samples.

NOTE C.—Proceed with the color matching as rapidly as possible after the thiocyanate has been added and the solutions have been added to the Nessler tubes. Do not attempt to grade more than six sample portions at one time, because of the gradual fading of the color.

NOTE D.—A Roulette Nessler tube rack such as the Fisher Scientific Co.'s Nesslerimeter is used for the color comparison, the unknown samples being placed in the rotor.

15. Calculation:

$$\frac{\text{Ml. std. Fe sol.} \times 0.00001 \times 100}{\text{Wt. of sample in Step 10 aliquot}} = \text{percent Fe}$$

DETERMINATION OF CHLORIDE CONTENT

Application.—To the determination of the chloride content of titanium metal sponge.

Outline.—The sample is dissolved in hydrofluoric acid without heating and boric acid is added. The chloride is then precipitated in the presence of nitric acid with silver nitrate. The precipitate is purified by solution in ammonium hydroxide and reprecipitation as silver chloride in which form it is filtered, dried and weighed.

Equipment.—

Beakers, plastic, 500 ml.
Beakers, Pyrex, 400 ml.
Filter paper, Muncktell 00, 12.5 cm.
Funnels, 60°
Gooch crucibles, Pyrex, fritted, fine porosity.
Filter flask.
Drying oven at 130° to 150° C.
Hydrofluoric acid, 48%.
Boric acid, powder.
Nitric acid, conc. C. P.
Silver nitrate, approx. N/10.
Silver nitrate, wash solution, 0.05 gm. $AgNO_3$/liter.
Ammonium hydroxide, 1–1.
Methyl orange indicator.

Procedure.—1. Measure 50 ml. distilled water and 20 ml. hydrofluoric acid into a 500 ml. plastic beaker and mix.

2. Riffle out about 5 gms. of sample. Weigh accurately and add in small portions to the diluted hydrofluoric acid solution. After all the metal has been added, allow to stand 15 minutes or until solution is complete.

3. Add 5.0 grams of boric acid and transfer solution to a 400 ml. Pyrex beaker.

4. Dilute to 200 ml.

5. Add 5.0 ml. nitric acid.

6. Stir while heating until solution becomes colorless.

7. Add N/10 silver nitrate solution in excess (10.0 ml. is usually sufficient) and stir until precipitate coagulates.

8. Allow to stand in dark closet for 2 hours.

9. Filter thru a close paper and wash thoroughly with a solution of silver nitrate containing 0.05 g. of silver nitrate per liter.

10. Dissolve the precipitate by pouring 50 ml. of ammonium hydroxide (1–1) thru the filter catching the filtrate in the original beaker. Pour the ammonium hydroxide thru a second time if necessary to dissolve the silver chloride.

11. Wash the paper thoroughly with water.

12. Make the filtrate slightly acid with nitric acid (methyl orange indicator), add 5 ml. N/10 silver nitrate solution and stir to coagulate the precipitate.
13. Allow to stand in dark closet for 2 hours.
14. Filter thru a tared fine porosity pyrex fritted crucible, police the beaker and stirring rod and wash thoroughly with a solution of silver nitrate containing 0.05 g. of silver nitrate per liter and then twice with water to remove the silver nitrate.
15. Dry the crucible and contents in an oven at 130 to 150° C.
16. Cool in a dessicator and weigh.

Calculation.—Wt. AgCl x 0.2474 x 100/sample weight=percent Cl.

DETERMINATION OF MAGNESIUM

Application.—To the determination of magnesium content of titanium metal in sponge form.

Outline.—The sample is dissolved in dilute sulfuric acid. Magnesium is precipitated with sodium hydroxide in the presence of hydrogen peroxide, thus separating it from most of the titanium. The resulting magnesium hydroxide is dissolved in dilute hydrochloric acid, the remainder of the titanium and iron separated by precipitation with ammonium hydroxide, and magnesium is determined in the filtrate by the addition of 8-hydroxyquinoline. The resulting precipitate is filtered, dried and weighed as $Mg(C_9H_6ON)_2$.

Equipment.—
Beakers, 600 ml., 400 ml.
Flasks, suction, 500 ml.
Buchner funnels, 350 ml. fritted glass medium porosity.
Gooch crucibles, fritted glass medium porosity, 30 mm.
Filter paper #30 Whatman, 12.5 cm.
Sodium hydroxide solution, dissolve 350 g. NaOH in water and dilute to 1 liter.
Hydrogen peroxide, 30 percent solution.
Sodium hydroxide wash solution, dissolve 10 g. HaOH in 1 liter of water.
Ammonium hydroxide, conc. solution.
Ammonium hydroxide wash solution, 10 ml. conc. ammonium hydroxide per liter of water.
8-hydroxyquinoline solution, dissolve 5 g. of the salt in 10 ml. glacial acetic acid and dilute to 100 ml. with water. The solution does not keep well and should be made fresh daily.

Procedure.—1. Measure out 200 ml. of the solution from step 8 in the procedure for the determination of the iron and transfer to a 600 ml. beaker.
2. Add 150 ml. of sodium hydroxide solution while stirring.
3. Heat to boiling and boil for five minutes.
4. Cool to approximately 50°C.
5. Add 35 ml. hydrogen peroxide (30 percent) and stir gently until TiO_2 has dissolved. See Note A.
6. Filter through a 350 ml. fritted glass Buchner funnel (medium porosity) and wash with hot 1 percent sodium hydroxide solution.
7. Discard the filtrate and rinse filter flask with distilled water.
8. Dissolve the precipitate off the filter with 40 ml. hot 1–3 hydrochloric acid, and wash with hot water.
9. Transfer the solution to a 400 ml. beaker.
10. Make ammoniacal. Add 5 ml. ammonium hydroxide in excess.
11. Boil for 5 minutes.
12. Filter and wash with hot water.
13. Add 5 ml. ammonium hydroxide.
14. Add 5 or 10 ml. 8-hydroxyquinoline solution depending on magnesium content and heat to boiling.
15. Remove from heat and allow to stand 15 or 20 minutes.
16. Filter on weighed fritted glass crucible and wash with hot dilute ammonium hydroxide solution (1–99).
17. Dry in oven for 2 hours at 130–140° C.
18. Cool in a desiccator and weigh.

Calculation.—

$$\frac{\text{Weight of precipitate} \times 7.79}{\text{Weight of sample in aliquot}} = \text{percent Mg}$$

NOTE A.—If all of the titanium does not go into solution after approximately 10 minutes, add more sodium hydroxide and hydrogen peroxide until solution of titanium is complete.

DETERMINATION OF CARBON

Application.—To the determination of carbon content of titanium metal in sponge form.

Outline.—The sample is burned in a combustion train and the CO_2 formed is collected in an absorption bulb containing Ascarite. The carbon is determined by weighing the bulb.

Equipment.—

Sentry Model V, Size 2, High Temperature Combustion Furnace equipped with thermocouple and combustion tube
Silica combustion Boats 6" long x ¾" wide x ⅜" deep. Made from silica tubing cut in half and ends sealed
Mercury Pressure Gauge and Safety Valve
Gas Washing Bottle
Safety Bottle (500 ml. W. M. Bottle)
Zinc Absorption Tube
Purifying Jar and Bubble Counter
Absorption Bulb (Stetser-Norton)
Asbestos
Ascarite
Mercury
Zinc Metal, 20-mesh
Oxygen
Sulphuric Acid (conc.)
Glass Wool
Drierite
Alundum, RR 60-mesh
Tin Metal, C. P. 30-mesh
Silver Sulphate, C. P. powder
Ingot Iron, 0.01 percent C or less. (B. of S. Standard Sample #55C is used in this laboratory)

Procedure.—1. Set up combustion train in the following order.

(a) Cylinder of oxygen.
(b) Mercury valve.
(c) Empty safety bottle.
(d) Gas washing bottle containing concentrated H_2SO_4
(e) Drying tube containing Ascarite with a layer of Drierite on top.
(f) Combustion furnace with combustion tube, the outlet of which is filled with previously ignited asbestos.
(g) A U-tube containing 20 mesh zinc in the arm adjacent to the combustion tube and silver sulphate in the other arm, the chemicals being separated by a layer of glass wool.
(h) A H_2SO_4 bulb. (Purifying jar)
(i) A U-tube containing Drierite.
(j) The absorption bulb.

2. To prepare the absorption bulb, place a layer of glass wool in the bottom, then add Ascarite until the bulb is almost full, then a layer of Drierite, then a layer of glass wool. One bulb should absorb about 10 g. of CO_2.

3. To standardize the absorption bulb, attach it to train in which the combustion tube has reached maximum temperature (2400° F.), turn on oxygen and at the end of 30 minutes, remove bulb and weigh. Repeat this process until the bulb has reached a constant weight.

4. Weigh 2.727 grams of the metal turnings and transfer to a silica boat which has been lined with a layer of alundum. Spread the sample uniformly throughout the length of the boat.

5. Weigh 2.5 grams of ingot iron and spread uniformly over the metal turnings.

6. Cover with a thin layer of tin metal, and finally with a layer of alundum.

7. Attach weighed absorption bulb to end of train.

8. Place boat containing sample into combustion tube, quickly insert rubber stopper in tube, and heat for 1 or 2 minutes without oxygen.

9. Turn on oxygen and burn sample for 15 minutes, maintaining temperature at 2400° F. and the flow of oxygen thru the tube should be regulated to the point

where the bubbles in the purifying jar form at a rate of approximately 150 per minute.

10. After sample is burned disconnect absorption bulb and place in balance case for 10 minutes.

11. Weigh, the increase in weight being CO_2.

12. Calculation when factor wt. sample is used. gm. CO_2—Blank×10=percent C. in sample.

NOTES.—1. A blank determination using all reagents except the sample should he run 30 minutes after the furnace has reached 2400° F.

2. The absorption bulbs should be allowed to remain in balance case for 10 minutes before weighing.

3. A Bureau of Standards standard steel of approximately the same carbon content as the samples to be analyzed is run daily.

4. New boats should be heated in the furnace with oxygen for 4 or 5 minutes before using.

5. After the determination is made the slag can be removed from the boat and the boat used again.

HARDNESS DETERMINATION

Application.—To determine the Brinell hardness of titanium metal sponge.

Outline.—Two 100-gram samples of titanium sponge are arc melted in a helium atmosphere. The resulting buttons (ingots) of metal are prepared for hardness by belt grinding. Brinell hardness is determined. See Figure 3.

Equipment.—1. The melting furnace consists of a ¼" or 5/16" water-cooled tungsten electrode and a water-cooled copper crucible (Fig. 3). Provision is made to purge the furnace by evacuation. A vacuum of less than 30 microns and a leak rate of less than 10 microns per minute is specified to minimize air contamination during melting. It is suggested that a graphite arc starter block or other means of arc starting be provided. Direct striking on the sponge can be used; however, it shortens electrode life and introduces possible tungsten contamination.

2. Helium, Grade A, double charcoal refined.

3. Two belt grinders, Buehler Ltd. #1250 belt surface or equivalent machine, provided with 80 and 150 grit belts.

4. Brinell hardness tester.

5. Representative sponge samples (100 grams). Section B (2) (b).

Procedure.—Melting:

1. Charge the crucible with one of the 100 gm. samples obtained.

2. Seal the furnace, pump down to a vacuum of less than 30 microns.

3. Bleed in helium to atmospheric pressure; allow helium to flow for about 30 seconds.

4. Pump down furnace to less than 30 microns; bleed in helium until furnace vacuum is 10 to 15 inches of mercury.

5. Turn on electrode and crucible water supply.

6. Strike arc on graphite starter block, using a DC current of 200 amps., 30 V. When sponge has melted into the form of a button, increase current to 450 amps. to assure thorough melting of the sample. Melting for a period of about 1½ to 2 minutes is required to outgas the melt. The completion of outgassing is indicated by a quiet pool. Maintain an arc length of about 1" during early melt-down, when pool is quiet shorten arc to about ¼" to concentrate heat and promote deep melting.

7. Shut off electrode water supply when electrode has ceased to glow. Shut off crucible water supply approximately 1 minute after the button has ceased to glow. These precautions are taken to maintain the water-cooled parts at room temperature, thereby preventing condensation of water on furnace parts when the furnace is opened.

8. Bleed in helium to atmospheric pressure, open furnace.

9. Caution: Remove buttons from crucible and tongs. The black deposits on the crucible walls are pyrophoric and frequently burn spontaneously when exposed to the air, or when disturbed during button removal.

10. Clean entire furnace between runs using coarse stainless steel wool to clean the crucible. Knock off any titanium particles that may stick to the crucible wall.

11. Examine electrode; if electrode tip is approximately the same shape as before melting and free of balling from the formation of a low melting titanium-tungsten alloy, it does not need replacement. Up to 20 melts have been obtained without changing electrodes.

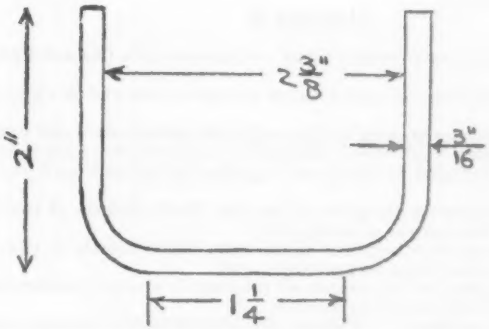
Hardness determination.—1. Grind bottom of button on 40 grit belt to provide a flat surface.

2. Grind top of button, flat and parallel to the button bottom, using 40 and 80 grit belts. Grind until a hardness testing surface about 1¼" in diameter is obtained.

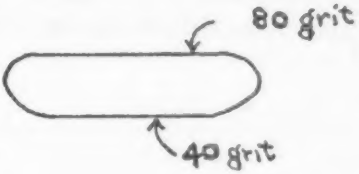
3. Allow the button to come to room temperature previous to hardness testing.

4. Make 2 Brinell hardness impressions located as shown in Fig. 3.

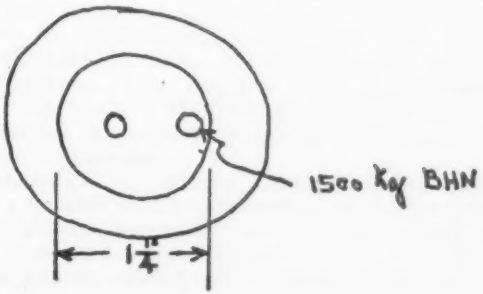
5. Average the values obtained from the two buttons for each sample; if the button values are widely divergent, i. e., greater than 20 points Brinnell, repeat the test.



WATER COOLED COPPER CRUCIBLE



SURFACED BUTTON



LOCATION OF HARDNESS IMPRESSIONS

FIGURE 3

APPENDIX B

CONTRACT BETWEEN UNITED STATES OF AMERICA AND CRAMET INC.

DEPARTMENT OF JUSTICE SCHEDULE OF ROYALTY PAYMENTS FOR USE OF KROLL PROCESS

Licensee for the licenses granted to him under the patent, shall pay to Licensor for all titanium which it shall use or sell and manufacture hereunder in accordance with a process claimed in the patent royalties at the following per annum rates:

1. 5 percent of the gross sales price of the first 50,000 pounds of titanium, in sponge, powder and ingot form so produced;
2. 3 percent of the gross sales price on the next 50,000 pounds of titanium, in sponge, powder and ingot form so produced; and
3. 1 percent of the gross sales price on all titanium in sponge, powder and ingot form in excess of 100,000 pounds so produced.

By the term "gross sales price" is meant the price charged to the customer irrespective of all deductions and discounts or trade allowances granted to the customer. Products shall be considered sold and subject to royalty accounting when billed out to the customer. Sponge, powder and ingot products transferred interdepartmentally or intracompany for use by the department or company, and not for resale as sponge, powder or ingot to the public, shall be accountable for payment of royalties at the time of such transfer and at the regular price charged to the public for the same product. Where ingot metal is fabricated in accordance with the process of Claim #13 of the patent, the royalty due shall be paid on the basis of the sales price of the resulting fabricated metal.

(Whereupon, at 11:05 a. m., the hearing was recessed subject to the call of the Chair.)

STOCKPILE AND ACCESSIBILITY OF STRATEGIC AND CRITICAL MATERIALS TO THE UNITED STATES IN TIME OF WAR

Titanium

WEDNESDAY, APRIL 7, 1954

UNITED STATES SENATE,
SPECIAL SUBCOMMITTEE ON MINERALS,
MATERIALS, AND FUEL ECONOMICS, OF THE
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met, pursuant to call, at 10:15 a. m., in the committee room, 224 Senate Office Building, Washington, D. C., Senator George W. Malone, chairman of the subcommittee, presiding.

Present: Senator George W. Malone, Nevada (chairman of the subcommittee).

Also present: Jerome S. Adlerman, counsel to the subcommittee; and George B. Holderer, subcommittee staff engineer.

Senator MALONE. The subcommittee will be in order.

We have asked you gentlemen to be present this morning because, as you know, for the last several months we have conducted a rather intensive study on numerous materials, and titanium was one of the main materials.

We have asked Roy T. Hurley, chairman of the board of Curtiss-Wright Corp., to be present, because his company is one of the outstanding potential users of titanium; Dr. Arthur S. Flemming, the Director of the Office of Defense Mobilization; Gen. Kern D. Metzger, of the Air Materiel Command, Wright-Patterson Air Force Base; Edmund F. Mansure, Administrator, General Services Administration; and Prof. Herbert H. Kellogg, from Columbia University, who has been put in charge particularly of the titanium use and production by Dr. Flemming.

This metal has been called the "wonder" metal. It has been said by witnesses that it is a "must" in the construction of lightweight and high-strength materials, and especially in the airplane field, where light weight is necessary and where strength is necessary. Its noncorrosive qualities and many other qualities make it, they say, indispensable.

One of the reasons for this meeting this morning is to sum up the use of this material. The committee is about through with its hearings and will now prepare its report. As a matter of fact, we have been preparing parts of the report for some time.

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TOO MUCH TITANIUM?

We have heard rumors—and you all understand how information gets about in Washington—that we have too much titanium. If we have too much titanium, practically all of the information that the committee has been able to secure for the past 4 months has been loaded information. The chairman can understand, as an industrial engineer, that there might temporarily be an overproduction. We also have had testimony from Don Douglas of the Douglas Aircraft Corp., Bob Gross of Lockheed, and many other users of titanium in their aircraft construction, that they are unable to take these plans for new aircraft off the board because they simply cannot start construction until they are sure that the going-concern manufacture of titanium will be sufficient to keep them going.

We have been on this business for about 3½ years now. The one agency, the one company that has had a contract for that length of time has never reached the limit of its contract, and while it has supplied the titanium, we are given to understand, making good on its contract requirements, specifications, hardness, et cetera, perhaps even the Government was not too fully informed as to just what the specifications should be, and I think no fault attaches, because it was a new metal. We are very short of the metal.

The experts and builders of these planes testified that when this lightweight metal is designed into a plane, it will result in a saving of over eight pounds in the airframe for each pound of weight saved by using titanium in place of stainless steel.

DISTURBING FACTORS

Another thing disturbs us—and as yet we have had no particular move in the right direction as far as we can see—in the contract with the Titanium Corp. at Henderson, Nev. We receive and ship the material rutile from Australia. We have no objection to getting rutile from Australia, but it would not be available, according to other testimony we have, when war starts. I understand we are getting near to a war, unless we are misinformed here on the Hill, hoping we will not have it but getting ready for it.

The du Pont Corp., producing 2½ tons in New Jersey, have developed some sources of material in this country, but have been getting a large amount of the ilmenite from India, which also the testimony shows would be unavailable. Also the testimony shows that there is enough ilmenite in the United States and southern Canada to last the whole hemisphere for 100 years. So it seems to this committee that we should start doing something about it.

Also the testimony shows that we are producing about 2,000 tons annually, and Don Douglas of Douglas Aircraft, Bob Gross of Lockheed, General Metzger at Wright Field, and engine company representatives have testified, and it all adds up that we need about 150,000 tons per year, and we are making about 2,000 tons.

The hearing has been called this morning with the specific idea of finding where this overproduction is, what is happening to it, and where the rumors come from. This committee will not disband until they find out.

The first man I am going to ask to make a statement as to what use this metal can be put to, what good it will do, what it will do for aircraft manufacture, and the amount of it they will need, to speak for his own engine company and generally for the industry, I understand, as chairman—and we have not studied the evidence and drawn any conclusions—that with what we have so far, if we do not develop a going-concern titanium manufacturing business to the extent necessary to take these plans off the drafting board and the engines, and have enough of it so we can support the production, and if Russia has what some of us believe they could easily have, enough titanium to put in their planes, we will have a second-best Air Corps; and a second-best Air Corps, as has been testified here before, is a good deal like a second-best poker hand. They do not count it.

SOVIET KNOW-HOW

Evidence has been presented to this committee that there have been at least 257 articles on titanium written by Russian metallurgists and scientists in the last few years. If they have gone to all that trouble, it is the opinion of the chairman that they are probably making some of it.

We know Japan is making it and offering it for sale in this country. Naturally, you could get it cheaper from Japan, because they work for 15 cents an hour over there, but you cannot get it from Japan when war starts. You cannot get it from England, either. We can get it from the United States, and we have everything in the world here to manufacture it with and for.

I am going to ask you, Mr. Hurley, as chairman of the Board of Curtiss-Wright Corp., to give us some information which will be an extension of your testimony given when you appeared before this committee previously. We want to know what can be done with it, what the specifications must be, what, in your opinion, is the likelihood of getting the price reduced. We know now it is costing about $15 a pound for metal and about $20 a pound for shapes, but even at that price, Don Douglas and Bob Gross testified they wanted all they could get of it.

You have testified you wanted all you could get of it at that price. The Monsanto Chemical Co. and other chemical companies have testified and written that they want all they can get at the present price.

Naturally, it would be more attractive if you had a lower price, and we all think it will be sold at a lower price when the time comes, if we can get it for steady use.

Furthermore, as is true of the history of all metals, even aluminum cost $50 a pound to start off with, but having gone into bulk use it does not cost very much now.

I point out that at the present price, according to testimony here, you could use all of the titanium you could possibly manufacture in the next 5 or 10 years in private industry; and if you take advantage of it, it is the opinion of the chairman at the moment—I do not think it will be changed—that you are going to have a civilian industry for going-concern titanium manufacture in this country so in a relatively short time we will not have to worry about the amount for national

defense. It can be simply diverted as we do steel now when war comes.

Mr. Hurley, will you proceed in your own way and tell us what you know about it?

FURTHER STATEMENT OF ROY T. HURLEY, CHAIRMAN OF THE BOARD, CURTISS-WRIGHT CORP.

Mr. HURLEY. Senator, referring back to my testimony before the committee on my last appearance, we have examined the situation very carefully again and we have worked very carefully with the Air Force, which has cognizance of our engine plants.

We talked a little bit when I was here before about risk, and I will say to you this morning that our examination shows that the only risk is that we not have enough metal or that we have it too late.

There was some talk about reluctance. At that time I said we had no reluctance about using the metal; that there was need for it. In the period following that first appearance we had a meeting with 5 vendors of the metal, arranged for by the Air Force under General Metzger's direction, and we have discussed with those 5 suppliers the metal that they can provide for the next 2 years. I found no reluctance on their part.

So I believe we can wipe the two horrors, risk and reluctance, out of the picture and forget about them.

The third important item developed was cost, and we have looked into the cost situation very carefully. It is our opinion that the thing to do to reduce cost is to put it into production; and in putting it into production very substantial savings can be made.

Senator, we have prepared some documents that I would like to leave with the committee. One is a study of the use of titanium. The second is the parts that we make of titanium. The third is a report that we prepared for the Air Force as a result of 2 years of work as to how to machine and fabricate.

If that program is put into effect, I would venture to predict that we would be shortly in the position of having a shortage of material, and that the cost would be reduced to something we can afford.

Senator MALONE. I notice, Mr. Hurley, it is marked "Confidential." It is not confidential any more?

Mr. HURLEY. It was confidential to our company. There is no classified information in the document that I know of, but we can review it with the Air Force to determine whether there is any military security involved.

Senator MALONE. These three documents will be accepted as exhibits 1, 2, and 3, and will be available to the committee in connection with your testimony.

(The documents referred to were marked "Exhibits Nos. 1, 2, and 3," and are available in the committee files.)

Senator MALONE. Go right ahead.

CONFIDENT OF COST REDUCTION

Mr. HURLEY. We have examined the cost of sponge. That causes no difficulty today. We have examined the cost of reducing the sponge to structural shapes. There we think by going into a day-to-

day production of a form or a part, the cost will be reduced. We are confident of that.

The next step is to fabricate the form or structure, the extrusion or the forging, so that we size the titanium forging or extrusion closely to the finished dimension of the piece. In those two steps the greatest cost reduction will take place in the immediate future.

There is no way that you can accomplish those cost reductions until you go into production and use it. When you go into production and use it, I think the reduction in cost will come automatically.

Senator MALONE. Do you have any idea or have there been any estimates of how much production might take place in the reasonably near future?

Mr. HURLEY. Senator, we set up a baseline in this way: We decided that if the use of a pound of titanium or a given titanium part would pay for itself in approximately 3 years, then it would be foolish for us not to put it in the engine. It is our intention to take piece after piece, and using that yardstick as to the economic value of the piece, determine whether it can be produced within those cost limitations; and if we do produce it within those cost limitations, ask that the Air Force amend our contracts to put those pieces into production.

Senator MALONE. Do I understand you in this connection that you would, instead of trying to make an entire engine, that is to say, use material immediately in every piece titanium would be applicable to, you will fit the number of pieces and the amount of titanium you are going to use into the amount available?

Mr. HURLEY. That is right.

Senator MALONE. And one piece at a time?

Mr. HURLEY. That is right.

Senator MALONE. In other words, if you have enough titanium over the next 6 months or a year, or from then on, for one certain piece only, then you will adopt only that piece?

Mr. HURLEY. As soon as we put that piece in the engine, we want to leave it in the engine. Every day that we produce that engine, that piece will go into it.

Senator MALONE. You will not start using it until we know the supply is adequate?

Mr. HURLEY. That the supply is adequate and that we can do it at a price that the Air Force can pay. We recognize both of those.

Senator MALONE. We have had testimony from the Air Force that cost, at the moment, is not the controlling factor.

If I understand you, right at the moment there is a very limited number of these pieces that you can start to use. How much is available to you?

Mr. HURLEY. Senator, there is a chart in that study that shows the availability of sponge and forms, and the amount that we could use, and the rate at which we could use it, the one w ith the gray cover, sir. We have tried to get away from abstract factors. There is the availability of sponge and metal, and this is what we can use [indicating]. That would indicate that there would be enough metal for our company and maybe one other company with a similar program.

Senator MALONE. Have you been assured that this amount will be available to you at the moment?

Mr. HURLEY. I am sure that General Metzger will allocate the metal to us that we need to do the job, if it is available, and we believe that metal is available and can be used.

If we do that, and one other company does it, we will use up the entire supply.

I think, Senator, the talk about an oversupply has developed because the suppliers of metal have not had productive outlets where they have had a constant requirement each month to use the metal and put it in production. That has caused, in their mind, the uncertainey; and we propose to wipe out that uncertainty.

Senator MALONE. Why has it not been done before?

Mr. HURLEY. Senator, I am afraid that we, for one, are guilty of not having looked into it carefully enough and dug deep enough into the situation.

Senator MALONE. What happens and what has happened in the past? Are those responsible for letting the contracts not in close enough contact with the actual users of the metal?

Mr. HURLEY. Our system of doing things has become so big and so involved that we very frequently make decisions without getting back to the man who is doing the job. It is amazing to me how often decisions are made or opinions are developed and public statements made without giving consideration to the man who is on the job who has to use the material or the device.

COMMITTEE URGENCE

For example, we know that if there is going to be a shortage of nickel, we are in trouble; and titanium is a substitute for nickel! If for no other reason than that, we should get busy and push it. I must confess that we have not in the past gone into the thing as deeply as we have as a result of being sparked by your committee and appearing before your committee.

Senator MALONE. I can only say to you, Mr. Hurley, that we covered quite a wide spread. We called the actual producers of titanium in Henderson and in New Jersey. We called the makers of the planes, Douglas Aircraft, Lockheed, and many others. We called the engine-makers, such as yourself. Then we called the GSA, and Dr. Flemming has been kind enough to appear here, this is the third time, and I hope that we do not have to bother him any more, because I know he has a lot of troubles of his own.

These undercurrent rumors around Washington do not add up. God knows how they start. They come out or organizations, and I do not believe from the heads of organizations. We have heard perhaps 20 or 25 of these organizations that go by initials, and every one of them apparently doing a very good job according to their lights, and good, honest men in charge of them, but neither knows what the other is doing as a general rule.

After you have heard about 20 of them, they begin to make a pattern, which is not to speed things up or to make us independent in the manufacture or production of anything, but in some cases to slow it down and, in nearly every case, we find, to make us dependent for something that we need to do that job, across one or both major oceans.

That is where we get into Senate Resolution 143, the availability to the United States during wartime.

If there is any reluctance on the part of the engine companies or the plane manufacturers to buy this material and put it into their equipment, and if there is an overproduction, we will have to change radically our impression up to date. That is the reason we called you. I remember your other testimony.

As I understand you now, instead of making a sample engine having everything in it, you are going to measure piece by piece against the supply, and General Metzger, whom we will hear later, you think will allocate the amount of titanium to you that you need for piece-by-piece addition to your engine.

Mr. HURLEY. That is right.

Senator MALONE. If you could get all the titanium you needed and were assured of it and put all of these pieces you have in your engine, if this little rumor that we pick up is true that there is more than you know what to do with, how much could you use in the course of a year, your annual use?

COULD USE 200 TONS MONTHLY

Mr. HURLEY. Senator, this shows month by month that we would use about 200 tons in the year 1955, if this program were released now, and that involves only our J–65 engine. By that time our J–67 engine should be in production, and that would take upward of another 100 tons. We are there getting up close to 300 tons, and this availability curve that we have shows that there will be at that time only about 380 tons available.

Senator MALONE. In other words, there would not be——

Mr. HURLEY. In other words, we would be using almost all the titanium metal that is available, based on the reports that have been given to us by these companies and the letters in these reports from the companies.

I would like to say to you, Senator, that pursuant to——

Senator MALONE. Then right at the moment, no one else would get any titanium but you?

Mr. HURLEY. We would use most of it under that program if that program were put into effect and were successful.

Senator MALONE. Instead of doing that, you propose to take only your share by putting in just piece by piece as you are assured there is a going-concern titanium manufacture to keep you moving from then on?

Mr. HURLEY. Yes. We have asked the vendors to tell us what material they have available they haven't orders for, and we are going to attenpt to use all the material they have by allocation.

Senator, I would like to say to you that as a result of the prior meeting or visit to your committee, General Metzger brought the suppliers of the metals and ourselves, the users of the metals, together, and this program is a result of the supplier of the metal and the user of the metal being brought together by the Air Force, and all the other agencies that I hear about are, let us say, for the moment sidetracked. I see no reason for their coming into this program. I would suggest to them, though, that they visit our people and look at what

we are doing and look at our plans, because to my knowledge they have not done that, and I think they should.

Senator MALONE. Who do you refer to in this regard?

Mr. HURLEY. Any other agency that is interested in titanium and the titanium program, any agency that has any doubt about the need for titanium or the way to use it or the cost of using it. I think they should come to us, the users, and say, "What is your experience, and what are you doing, and what are your plans?"

Senator MALONE. Would that include the agencies of the Government responsible for securing titanium?

M. HURLEY. I would say any agency, sir.

Senator MALONE. Have you investigated any other engine company to see what they would require in a similar situation?

INDUSTRY COOPERATION

Mr. HURLEY. I know the other engine companies are machining titanium and making pieces. We have had cooperation from the other companies, and their names are listed in that book. There are some 20 or 25 companies which have cooperated in that effort.

Senator MALONE. Would you say that by 1956, you would add up to 300 tons annually?

Mr. HURLEY. That is on a monthly basis. The monthly production requirements are scheduled on that chart, sir.

Senator MALONE. How much per month?

Mr. HURLEY. This is running here at a monthly rate of about 180 tons in February of 1955. If we bring in other engines in 1956, that requirement will go up.

Senator MALONE. Is that a monthly requirement?

Mr. HURLEY. That is a monthly requirement; yes, sir.

Senator MALONE. For 300 tons, if you had the two engines in production?

Mr. HURLEY. Yes, sir.

Senator MALONE. That is nearly twice as much as we are now producing, just for you alone.

Mr. HURLEY. Our chart shows here that in the month of April there will be about 200 tons, that the production will be at that rate.

Senator MALONE. That is for the month of April, right now?

Mr. HURLEY. In the month of February 1955, we will have just about reached that usage.

Senator MALONE. Per month?

Mr. HURLEY. Per month, that is right.

Senator MALONE. By 1956, you would use more than is now being produced, if you could get it.

Mr. HURLEY. Yes; we would.

Senator MALONE. How much would all these other companies probably demand if they knew they could get it and if they took their plans right off the board?

Mr. HURLEY. Senator, I have no figures to give you on that except to say that they should use in similar amounts and like quantities. I cannot talk for the airframe builders, but there are four other engine builders, and certainly if they used it to the same degree, their requirements would be in excess of the availability.

Senator MALONE. Would their requirements be equal to yours, do you think?

Mr. HURLEY. I am sure that we are not going to have most of the engine business. We just have a fair share. The Air Force has got to distribute the business among all the engine builders.

Senator MALONE. That would make about 800 tons a month.

EXCHANGE OF INFORMATION

Mr. HURLEY. I would like to say, Senator, that this work that we propose to do must be done by someone before this material can be put into use. We intend to do this work for the Air Force if it is given to us to do, on the basis of public service, and it should be made available to all companies. The things that we do to reduce costs or to improve the fabricating techniques should be made available to everybody. I do not think we should have 10 companies, for example, repeating this same effort. I think 1 or 2 should do it, and it should be made available to all.

Senator MALONE. That is a very good public service, and of course that always becomes a problem when the Government needs something so badly. Naturally, inventions and laboratory work, most companies feel are an investment. But you feel in this regard that it is public service for national defense.

AIR SUPREMACY VITAL

Mr. HURLEY. It is essential if we are to maintain air supremacy and have airpower. We cannot think of having a second-rate Air Force. We have to have a first-rate one.

Senator MALONE. This amount of titanium would add up, in your rough estimate, to around 10,000 tons a year for engines alone?

Mr. HURLEY. Something on that order, sir. I haven't multiplied that out.

I would like to touch on one other thing, if I may, Senator. There was discussion when we were here before about the inability to use scrap. At this meeting that was set up by General Metzger, we found that the vendors had developed improved techniques for using scrap, and the fear that we might find ourselves with terrific piles of chips and scraps in the country, it now appears to me that there has been enough advance made to feel confident that even that will be eliminated if we go into production.

Senator MALONE. That was left open in the hearings. No one had whipped the scrap proposition. Do you think you are reaching the point where you can make efficient use of a considerable amount of the scrap?

Mr. HURLEY. Some of the vendors said they could use up to 30 percent, and if they have gotten that far in this short period of time, I am sure that further improvement is possible which will carry it well beyond that.

TITANIUM ADVANTAGES

Senator MALONE. Tell us something about what titanium does for an engine in lightweight and the additional power per pound, and what it does for an airplane.

Mr. HURLEY. Senator, it allows you to operate at a higher temperature, which gives you more power and greater efficiency for a given weight or cost. It allows you to carry more fuel if you want to convert the saving to fuel and give you more range. It allows you to carry greater weight.

Senator MALONE. You can balance the load against the distance you must travel.

Mr. HURLEY. That is right. We put the DC-type of air transport airplane that the Douglas Co. manufactures, and used that, and we found that every pound of titanium that we could put in that airplane in the engine would pay back to the user of the airplane in 3 years the complete investment, and from then on it would be a complete profit.

Senator MALONE. Just for the benefit of the record, you might review what I think is in the record, just what is necessary to prepare these planes for sonic speeds, why it is necessary to use it, what could be the range of these long-range bombers, or whatever it is they intend to use this material for.

Mr. HURLEY. Senator, to maintain air supremacy for the Air Force to do a job, one of these days our air arm is going to have to do a job which I consider the most important military job which has ever been done in our freeman's way of life. This is going to be it. Either we retain what we have in our way of life, or we lose it. So it is an all-important operation to me.

The Air Forces, to do that job, have got to have superior speed. They can only get superior speed through more power. The more power they get, the bigger the airplane has got to become and the more fuel it has to carry. That is a rather vicious circle that you find yourself in.

So every time that you can take a pound out, it is like a pyramid. You save yourself in all directions. You get better economy, more power, more range; you can carry more weapons; you do a very much better job.

WEIGHT RATIO

Senator MALONE. What is the weight of the titanium, for the benefit of the record, in relation to steel and aluminum?

Mr. HURLEY. Roughly, I would estimate, sir, without giving specific figures, about half as much.

Senator MALONE. Here are a couple of samples. You can tell easily which one is titanium and which one is steel.

Mr. HURLEY. There is no question about it.

Senator MALONE. What is the weight ratio?

Mr. HURLEY. Roughly, I estimate about half. It depends upon the piece and the way you use it and the way you install it in the engine of the airplane.

Senator MALONE. But it has much greater strength per pound than even aluminum?

Mr. HURLEY. Oh, yes. Generally we plan to use these alloys where we would use steel rather than aluminum, because their physical properties are better and the resistance to temperature is better and their properties under high temperature are better.

Senator MALONE. But you do have to have something to stand greater heat than aluminum for the skin of the plane, the outside of the airplane for these sonic speeds, is that right?

Mr. HURLEY. That is right.

Senator MALONE. Mr. Hurley, does that complete your statement?

Mr. HURLEY. Yes.

Senator MALONE. If you will remain with us, we may call you again.

Now I would like to call Mr. Mansure, who is the Administrator of the GSA and is responsible for contracts for titanium.

FURTHER STATEMENT OF EDMUND F. MANSURE, ADMINISTRATOR, GENERAL SERVICES ADMINISTRATION

Senator MALONE. Mr. Mansure, you have been before the committee before.

Mr. MANSURE. Yes, sir.

Senator MALONE. You know the great interest of the committee in the production of titanium. We were just a little perturbed about the rumors, wherever they were, around Washington that began to take root that we had too much titanium. You are right in the middle of this deal. We would like to have you tell us what you think about it, and also what progress you have made since you appeared here before, in additional production.

Mr. MANSURE. I suppose there will always be rumors, but as far as GSA is concerned, we are doing everything we possibly can to further the production of titanium.

Senator MALONE. Do you know of any overproduction?

Mr. MANSURE. We have given you a report—I think you received our last letter—on just where we stand. I will not go over the details on that, but you can see from that that progress has been made.

Senator MALONE. You can tell us anything that is of a public nature. I would not ask you for anything that you would like to keep confidential, until you complete the contract, but if you have anything in the way of progress you would like to put in the record, just give it to us.

Mr. MANSURE. I have nothing further unless you have some questions on our most recent report on the production.

SPIKES RUMORS

Senator MALONE. My question is a $64 one: Do we have too much titanium?

Mr. MANSURE. Not to our knowledge, but of course we have to have the users of this titanium actually put it into production as we move along. The big problem is——

Senator MALONE. Where does this idea that there is too much titanium come from? It has come back to this committee two or three times.

Mr. MANSURE. I haven't heard it other than to hear it as you yourself said. I don't know where it comes from.

Senator MALONE. It does not come from your office?

Mr. MANSURE. It does not come from us, no. We would not be spending all this time trying to develop these new sources if this was our feeling.

Senator MALONE. The chairman of the committee, and I am sure the entire committee, can understand that, when you are in a business where you do not have anything with which to begin. You took over

last year and, according to your report to the committee, you are making progress. We can see an entirely new metal and an entirely new building material, and there is an extreme nervousness on the part of the plane builders and engine builders to start tooling up for a new product and not be able to get it. You understand that.

Mr. MANSURE. That is correct.

Senator MALONE. Therefore, there may be a period while you are trying to create a going concern in the manufacture of enough titanium each month and each year to justify the builders of engines and planes in going into the business and using it actually, tooling up for it. According to the testimony, in the next 5 years there cannot possibly be a surplus of titanium. Do you agree with that statement?

SURPLUS NOT ANTICIPATED

Mr. MANSURE. From all the information that we have; yes, sir.

Senator MALONE. Then do you suppose that there are some folks maybe in your agency or in some other agencies who do not have all the information, who may make these statements that get out to the public? Maybe they do not understand that the plans of these new war planes are on the boards ready to come off when we can assure them that you have the going-concern manufacture.

Mr. MANSURE. I doubt that that would be the case, because our people, particularly our Emergency Procurement Division, are perfectly cognizant of the uses that are going to be made of this metal. It is a difficult program that we are trying to develop, but the problem is very simple. It is to get the substantial people, the producers, so they can make the progress and develop this metal at a lower cost.

Of course, as we know, there are several companies that are just on the threshold in research of the development of cost reductions in their processes. We feel in GSA that, first of all, the doors are wide open. We have the best companies in the country working on this. If any other company wants to come in to the picture, they have every opportunity in the world to present to us what they feel they can do, their facilities, and so forth. But it is purely a development problem that we are running into.

COST FACTOR

That is why we are not getting greater production at present. I do not believe these people are discussing the market for the metal. It is a cost factor which they are confronted with.

Senator MALONE. They are cognizant of the fact, and I know you are, that the demand is there for all you can get at the present cost, or are you?

Mr. MANSURE. Yes, we are, but I would not want to say whether all of the sponge that is going to be produced between now and, say, late summer—I do not know what demand there is right now.

Senator MALONE. Would you quit producing the sponge simply because you had not had enough of it over a period of time for people to start using it? Would you counsel shutting down on it or slowing up?

Mr. MANSURE. GSA does not do that. This is being produced by private industry, and private industry is interested in developing the greatest possible market.

Senator MALONE. This private industry is getting Government money, too, is it not?

Mr. MANSURE. True. And they are going to continue to produce all they possibly can as long as there is a purchaser for the product.

Senator MALONE. How much Government money is the Titanium Corp. getting out at Henderson, just roughly?

Mr. MANSURE. Irving, do you have those figures?

Mr. IRVING GUMBEL (Acting Director, Materials Division, Emergency Procurement Service, General Services Administration). $15 million.

Mr. MANSURE. Do you have the list there that I can have?

Senator MALONE. We are not going into it in detail. The Du Ponts are getting some money, too, are they not?

Mr. MANSURE. Yes.

Senator MALONE. How much?

Mr. GUMBEL. $12 million.

Mr. MANSURE. Twelve.

Give me that list and we can run right down on that.

Senator MALONE. It does not matter at all, you understand, but as long as they are getting Government money, they are getting it for one purpose, as the chairman of this committee understood, and that is to make titanium sponge and get it ready for the companies to make the metal. They are not holding back, are they, in making the titanium sponge, for a cheaper process?

Mr. MANSURE. No, they are not holding back for a cheaper process. What they are trying to do is exert every possible effort to develop this cheaper process, and that would be natural in any successfully operated company.

Senator MALONE. Of course, that is important, but there is a sale for all the metal you can get at the present price?

Mr. MANSURE. Do we have a market for all the metal we can get right now between now and midsummer, Al?

Senator MALONE. Come right up here. Get yourself a chair and come up behind your boss.

Mr. MANSURE. This is Mr. Walsh, Commissioner of Purchases and Procurement.

Senator MALONE. I met Mr. Walsh before, and he has been before us previously.

Mr. A. J. WALSH (Commissioner of Emergency Procurement Service, General Services Administration). There will be approximately 1,800,000 pounds generated between now and midsummer——

Senator MALONE. Of sponge?

Mr. WALSH. Yes. Which we are arranging to take and hold awaiting demand.

Senator MALONE. How much metal will that make?

Mr. WALSH. Frankly, I do not know.

Mr. MANSURE. I think we ought to clear up one point right there, Senator, that you are taking it awaiting demand. How about your demand right now for the next 90 days?

Mr. WALSH. We do not know what that demand is. Someone else would have to furnish that. I do not know.

Senator MALONE. Did you know, were you cognizant of the information that Mr. Hurley put into the record this morning, that they

are waiting to be assured that it is a going-concern production of titanium before they can adopt a method of using it?

FULL PRODUCTION

Mr. WALSH. Yes, sir. That is the reason we are arranging to keep this production going full force, to have supplies available.

Senator MALONE. Then you are cognizant of the fact that if there is no immediate demand this month or next month, the reason for it is that there is no dependable amount sufficient that they can go into the use of it and be assured that it will continue to be available?

Mr. WALSH. That is correct, sir.

Senator MALONE. Do you have any idea that any information is coming out of your organization that sifts around Washington that titanium is in oversupply?

Mr. WALSH. No, sir, we have not.

Senator MALONE. It is going to become a very important question about the next time this committee has to go into it.

Mr. WALSH. It would not be emanating from our organization, sir.

Mr. MANSURE. I would like to say further, Mr. Chairman, that regardless of what rumors may exist, that has no direction or effect on our operations at all. We have a job to do, and whatever curbstone comment is made has nothing to do with the program that we have set up. We have no control over opinions or expressions of view that are made.

Senator MALONE. They were repeated to the chairman by two or three very responsible people who did not know about it, and it was becoming just a little serious. You have 1,800,000 pounds. Mr. Walsh, how many tons would that be—about 900 tons?

Mr. WALSH. That would be 900 tons of sponge, yes, sir.

Senator MALONE. How long does it take to produce that sponge?

Mr. WALSH. It is not all produced yet. It will be produced by midsummer.

Senator MALONE. You heard the testimony that the engine companies alone probably could use 10,000 tons of titanium a year if they knew it would be available.

Mr. WALSH. Yes, sir.

Senator MALONE. Do you believe that?

Mr. WALSH. I have no way of knowing.

Senator MALONE. You do not disbelieve it?

Mr. WALSH. No, sir, I do not disbelieve it.

PRODUCING CONTRACTS

Senator MALONE. Would it be out of the way to put into the record here the progress you are making on these contracts, and who with, or would you rather not do that?

Mr. MANSURE. I do not think there is any objection, is there, Irving, to stating for the record the progress we are making on these contracts?

Mr. GUMBEL. No.

Mr. MANSURE. I think it would be good to put it into the record.

Senator MALONE. Go right ahead and give it to us. You understand we want nothing that would embarrass anyone in your negotiations, because we can do that later privately, as we have before.

Mr. MANSURE. Do you want me to read it, or do you just want——

Senator MALONE. You might read the summation.

Mr. MANSURE. I can give it to you quite quickly.

Du Pont Co.: Proposed contract provisions for expansion of capacity will be submitted on March 29 to the Office of Defense Mobilization for consideration in relation to the overall titanium program.

Electrometallurgical: Proposed contract provisions will be submitted to the Office of Defense Mobilization the week of March 29. Ten thousand tons per year production.

Dow Chemical: Proposed contract provision will be submitted to the Office of Defense Mobilization during week of March 29. Twelve hundred sixty to eighteen hundred tons per year capacity.

Du Pont again: Contractor requests certain changes in draft of revolving fund contract submitted for consideration on March 12. Revisions were made and final draft of contract mailed to contractor for signature week of March 22.

Titanium Metals Corp. of America: Revolving fund contract mailed to contractor March 24 for signature.

Horizon Titanium Corp.: First extensive negotiations conducted in meeting March 24 between contractor and Government representatives. Contract now being drafted.

Monsanto Chemical Co. and National Research Corp.: Further conversations with representatives of Monsanto and National Research March 25 resulted in invitation to file proposal employing company's tetrachloride process, coupled with Kroll process reduction plant for 3,000 tons annual capacity.

Aerometals, Las Vegas, Nev.: Full technical report expected from expansion branch week of March 29 to permit start of contract negotiations.

Western Pyromet Co.: Permission not yet received from Department of Defense to convert part of Manteca magnesium plant to experimental titanium work.

Status of executed contract is as follows:

Du Pont decision on proposed purchase commitment to permit commencement of operation facilities at capacity in June, 1954, not yet received from Office of Defense Mobilization.

Titanium Metals Corp. of America, status unchanged since March 12 report.

Cramet, Inc., project development to date indicates probable overrun in cost of construction of some $10 million. Contractor preparing request for increase in Government assistance.

Bureau of Mines pilot plant, Boulder City, Nev., continues to operate approximately 20 tons per month.

APPLICATIONS IN PROCESS

We have the applications in process. I won't go into the details on this, but they include Anaconda Copper Co., Wyandotte Chemical Co., Chicago Development Co., and Kaiser Aluminum and Chemical Corp.

Now we have other interests shown by Eagle-Picher Co. of Cincinnati, Columbia Southern Chemical, the Glidden Co., National Distillers Products Corp., New Jersey Zinc Co., and United International Research, Inc.

That brings us right up to date, Mr. Chairman.

Senator MALONE. Have you summarized it as to about the time that each one might be brought to a conclusion, and how many tons of production it represents, and when they would begin production?

Mr. MANSURE. To give you the estimated number of tons would be a pure guess.

Senator MALONE. Yes, of course. Just an estimate.

Mr. MANSURE. What are we shooting for for the remainder of this calendar year, Al?

Mr. WALSH. They have those figures here. I do not have them in mind.

Do you have the figures there for the remainder of the year?

Mr. MANSURE. The remainder of the calendar year. Come on up, Irving.

Approximately what do we estimate our production will be the remainder of this calendar year? We are guessing at it.

Mr. GUMBEL. Yes. Could I do a quick calculation?

Senator MALONE. We would like to have some idea, for the record, of the progress that you expect to make for this calendar year and, say, 1955.

INVENTORY BUILDUP

Mr. MANSURE. I think, Mr. Chairman, we can clear up a misunderstanding if we take the one specific question of the production that we are receiving right now, which some people are confusing with surplus. It is actually building up an inventory so that the engine companies can commence to use it on a steady basis. I think that is where your misunderstanding has arisen.

When we realize that, say that we grant that there may be some production which is not being called for right now, but there isn't a sufficient amount of metal that the engine manufacturer or the plane manufacturer can in turn go into production on. So we have in turn to have a backlog, and we haven't had that backlog. That is where the misunderstanding arises.

Senator MALONE. You either have to have a backlog or an inventory, or the going-concern production. Of course, the chairman understood that, but after it hit him 3 or 4 times, it began to get tiresome.

The only way to clear the thing up, especially as important as this is, was just to have the man in charge of it explain it. I think you have adequately explained it, coupled with Mr. Hurley's testimony, that whenever you can show an inventory and a going-concern capacity for production that will justify the engine companies in adopting piece by piece, as outlined to you, inclusion in the engines—and I have no doubt it would apply, if we had Don Douglas and Bob Gross come back here, equally to plane construction—then what it means is that you are starting to use a new product and you are just trying to satisfy the people who will use it that once they start to use it, they will not have to stop in the middle of construction and go back to the old methods.

Mr. MANSURE. Of course, you cannot do that when you are in large-scale production. You have to keep a steady flow.

Senator MALONE. That is right. You are now right in the middle of this preparation. That ought to explode, once and for all, all this business that we have too much titanium; don't you think.

Mr. MANSURE. Right.

Senator MALONE. In the last 3 months, the summation has been that you need 150,000 tons of titanium annually on the things that you have on the drafting board now and getting ready to manufacture, provided that you can be sure that you can get it on the barrelhead. You have had that information?

Mr. MANSURE. That is right.

Senator MALONE. Have you investigated it to determine to your own staisfaction that it has some basis in fact?

Mr. MANSURE. We have no means of investigating it, because what we do is procure whatever the material happens to be, whether it is titanium or some other product, upon the direction of the Office of Defense Mobilization.

Senator MALONE. It is not your job to determine need?

Mr. MANSURE. The need is up to the Department of Defense or the department which is using it. In other words, we are the service organization, so we do not take part in the decision on the amount of the need. We are instructed what that need is, and we go ahead and carry out the physical operations.

PRODUCTION GOALS

Senator MALONE. What are your instructions? What are our goals now?

Mr. MANSURE. Our present goals are what?

Mr. GUMBEL. Actually, 25,000 tons a year annual capacity as present, but Dr. Fleming has told us to go ahead and negotiate the contracts that we have in the mill, regardless of the fact that that would bring us above the 25,000.

Senator MALONE. Where would it bring you?

Mr. GUMBEL. It will bring us to about 31,000.

Mr. MANSURE. I want to emphasize that ODM has given GSA flexibility in negotiating these contracts.

Senator MALONE. When would reach this 31,000 tons? You are now 2,000 tons, roughly, are you not?

Mr. GUMBEL. Senator, you always have to consider that these plants come into production gradually.

Senator MALONE. Very gradually.

Mr. GUMBEL. Yes, sir. It takes 2 years before they can get into full production.

Senator MALONE. You have been letting these contracts very gradually, too, have you not?

Mr. GUMBEL. Senator, they are quite complicated.

Senator MALONE. They are complicated, but whenever you need a thing, whenever you have to have it, whenever it is testified by the plane makers and the plane users that it is a "must," is it not necessary to understand the complications pretty fast?

Mr. GUMBEL. That is true, sir.

Senator MALONE. The complications are not on your part particularly, except to know that the Government is properly protected and what risk the Government is going to take. The complications are for the company to establish a plant that will produce the titanium under the present conditions, and also conduct their experiments to arrive at any cheaper process that they can find. That is where the complications really are, is it not?

Mr. GUMBEL. Yes.

GOVERNMENT RISK

Senator MALONE. What chance does the Government take in these contracts? What gamble does the Government take?

Mr. GUMBEL. I do not consider that they are taking any very considerable risk.

Senator MALONE. I do not, either, but tell us what it is.

Mr. GUMBEL. Of course, there is the risk—and I think it is fairly remote—that a new process will come in and be put into production before these contracts run out.

Senator MALONE. Before they have repaid the money?

Mr. GUMBEL. That is right, sir. The contracts run for 5 years. Two of them, as you know, are already actually in production. The time is running now.

Senator MALONE. What is the second one in production?

Mr. GUMBEL. The Du Pont is in production.

Senator MALONE. They are not in production on your contract?

Mr. GUMBEL. They are substantially ready. Their subconstruction.

Senator MALONE. I think they testified they would start this month, but they have not yet started, have they?

Mr. GUMBEL. That is right.

Senator MALONE. When will they actually start?

Mr. GUMBEL. I think this month.

Senator MALONE. How much will that be?

Mr. GUMBEL. There again, it will be a gradual buildup.

Senator MALONE. They have a 7½ tons per day contract, have they not?

Mr. GUMBEL. That is right.

Senator MALONE. I was under the impression they had a 10-ton contract, but they testified they are producing 2½ tons a day on their own investment, having nothing to do with the Government contract.

If they start this month, when do you think they will come up to the 7 tons per day? What is their program?

Mr. GUMBEL. I would think about late summer.

Senator MALONE. That is the program?

Mr. GUMBEL. Yes.

Senator MALONE. These contracts that you read off to us today are simply in the offing, simply under consideration?

Mr. MANSURE. No, Senator.

Mr. GUMBEL. The three old contracts, the TMCA and the Du Pont plant, are well along and actually producing metal and will continue to increase their production until they reach capacity.

FOUR-TON PRODUCTION

Senator MALONE. Just so we do not confuse the record, there is only one company in production now under a Government contract?

Mr. GUMBEL. That is true.

Senator MALONE. And that is the Titanium Corp.?

Mr. GUMBEL. That is true.

Senator MALONE. How much are they making a day now?

Mr. GUMBEL. About 4 tons a day.

Senator MALONE. They were making just a little less than 4 tons about 4 or 5 months ago or 6 months ago when we held a hearing there. They haven't increased it much.

Mr. GUMBEL. They had to make some changes.

Senator MALONE. They have been making changes for 3 years now, have they not?

Mr. GUMBEL. You have heard the company. I think it has testified on that.

Senator MALONE. That is right. I have no fault to find with the company. But you are the organization that lets the contracts. What do you do to check these contracts when they do not make the progress that they are supposed to make?

Mr. GUMBEL. In that particular case, Senator, we asked the Bureau of Mines, who are our experts on the technical features of the manufacturing, to go out there and make a thorough survey of the plant.

Senator MALONE. Did they do it?

Mr. GUMBEL. They did, sir.

Senator MALONE. What is the matter with it?

Mr. GUMBEL. They said that they thought the company on the whole was doing a good job; that its plans for the necessary changes seemed reasonable, and they felt if they were put into effect promptly, the difficulties would be ironed out and the plant could get into at least the rated production.

Senator MALONE. When?

Mr. GUMBEL. My recollection is, sometime this fall.

Senator MALONE. When did you give them a contract?

Mr. GUMBEL. About 2 years ago, as I recall it.

Senator MALONE. When did you get this examination made by the Bureau of Mines?

Mr. GUMBEL. I think we asked them to make that somewhere after the turn of the year.

Senator MALONE. This year?

Mr. GUMBEL. This year.

Senator MALONE. In other words, there had been nothing done about it until the investigation started?

Mr. GUMBEL. They did not know and we would not have known that they were going to have any trouble until the plant was pretty well along, and we found out. You see, as you have often remarked, this is an infant industry. You design a plant and start building it, and it is not until you start making the wheels go around that you realize and find out that there are kinks in it.

Senator MALONE. Actually, your organization——

SPECIFICATIONS CHANGED

Mr. GUMBEL. Also, Senator, if I might mention this, which is something that you know, too, of course, that the specifications for the titanium have changed considerably since we first entered into this contract. Titanium that was satisfactory when the plant was designed is not satisfactory today.

Senator MALONE. I have often said here that I do not believe any agency is to blame for anything that has gone before, but let us pick it up now and do some business.

For 2 years, then, over 2 years, the Bureau of Mines engineers were not sent in to get a report on it. Why?

Mr. GUMBEL. Senator, it is a little difficult. You see, after all, these plants are owned by private enterprise.

Senator MALONE. They have Government money.

Mr. GUMBEL. They are financed by the Government, of course.

Senator MALONE. Fifteen million dollars of Government money.

Mr. GUMBEL. That is right. It has been our policy, to the extent possible, not to interfere with their operations. Very frequently when you start interfering and you haven't the necessary background, you cause more trouble than you do good.

Senator MALONE. You do not have experts on titanium with your organization?

Mr. GUMBEL. No.

Senator MALONE. But you do have available the engineers in the Bureau of Mines.

Mr. GUMBEL. That is right.

Senator MALONE. And the engineers in the Bureau of Mines perfected the process, did they not?

Mr. GUMBEL. Yes, sir.

Senator MALONE. They have always been at your beck and call?

Mr. GUMBEL. Yes, sir.

Senator MALONE. Did you, as a matter of fact, realize the importance of this material until recently?

Mr. GUMBEL. Oh, yes. We have always realized that.

Senator MALONE. Did you know that it was a must in planes and in the manufacture of war materials?

Mr. GUMBEL. For 2 years our principal efforts have been directed toward securing titanium.

Senator MALONE. Why did you not get this thing checked up before you did?

Mr. GUMBEL. Senator, there again it takes time to get these plants built, and it is only when the plant starts operating that you realize that there are "bugs" in it.

Senator MALONE. I will not pursue that any further. I think the record speaks for itself. I think that that is the only place where your organization might be subject to criticism, that you have not followed through with your contracts. But I do not think you are subject to criticism in setting the specifications, because the users did not know, either. It was a new metal. It was not known whether 224 hardness was the right specification in that regard. Now they need 160 or 170. You know that now. You did not know it then, and neither did they. So you are not to blame for that.

This committee has no idea of blaming anyone, anyhow. What we want to do is to help, and I think we are helping you today.

OBSOLESCENCE

Is there not a chance the Government is taking if you have a paragraph in your contract that if obsolescence occurs by virtue of new inventions or processes, the Government stands the loss?

Mr. GUMBEL. That is correct.

Senator MALONE. I think, as chairman of the committee—and I think the entire committee will agree with the chairman—that you are entirely justified in taking that chance, because no private company could afford to do it, but you are taking it.

Mr. GUMBEL. Yes.

Senator MALONE. You are hoping you lose some money, are you not? You should be.

Mr. GUMBEL. What we are really hoping for, Senator, is that when the new process comes in, there will still be such a demand for the metal that these obsolete plants will continue to operate in order to produce titanium until we are off the hook.

Senator MALONE. If they did not, let us put it this way: The Government is buying the material. Therefore, if you cut the price of titanium in two and got it to $7 a pound for the metal instead of $15, and you paid for the machinery and washed it out, you are still winning, are you not?

Mr. GUMBEL. That is right.

Senator MALONE. That is, you represent the Government, and somebody else represents the purchasing department, like the general here. So we add it all up and it comes back to the taxpayers in Reno and like precincts, anyway. So are we not winning anway?

Mr. GUMBEL. Surely.

Senator MALONE. I hope that you lose some money on obsolescence and quit.

I think, Mr. Mansure, that your statement today clearly sets forth the condition that, instead of having too much titanium, we have about one-seventh enough, and we cannot possibly get too much in the next 10 years. The testimony from the civilian users, Monsanto Chemical and others, is that the chemical industry would do the same as the war materials producers; that if they had it and could change over, they would change over overnight, even at the present price.

In my personal opinion now, not a conclusion because the conclusions will come later, my feeling is that you are headed for a great civilian industry, maybe five to ten billion dollars a year. After you reach that, there is no trouble in the War Department that you have not reached it. But only to the extent that your orders add up, not beyond 31,000 tons—how far does your leeway extend?

Mr. GUMBEL. Officially to 25,000.

Senator MALONE. But unofficially?

Mr. GUMBEL. That would, of course, depend upon what Dr. Flemming says.

Senator MALONE. How do you understand it if he dropped dead tomorrow?

Mr. GUMBEL. I have the feeling——

Mr. MANSURE. I can answer that. I think our understanding is that as rapidly as we can develop this, we can go ahead with it, but we have to keep ODM informed of what we are doing.

Senator MALONE. In other words, he would not stop you if you had not hit the 150,000 you need? You do not think he would, do you?

Mr. MANSURE. If we have the money.

Senator MALONE. That is where we come in. In other words, how can we go before the Senate and say we want a certain amount of money. "What do you want it for? You cannot buy anything for it." But you will have no embarrassment, I am sure, and the general will have no embarrassment, to come before the Appropriations Committee, at least before any committees that I am a member of, and

say, "This is available and it is a must." He will get the money to buy it.

As far as you are concerned, as far as any rumor or anything, you are sure it is not coming out of your organization?

Mr. MANSURE. We know it is not coming out of our organization.

Senator MALONE. I hope you will do just a little checking there.

Mr. MANSURE. There is one more thing I want to clear up.

Senator MALONE. I do not want to have to bring you down again. If we do, we will go into your organization.

Mr. MANSURE. Regardless of all of this conversation on the improvement of the process, that is not guiding or straightjacketing our thinking at all in regard to the development of what processes are presently available.

Senator MALONE. I am glad you straightened that out.

Mr. MANSURE. They are two separate things. We are doing all that we can now with the tools that we have. If someone comes along with something better, that is another matter, which is not guiding our present thinking.

Senator MALONE. When they come along with something better, you will fulfill your contact on obsolescence of machinery and go right ahead and be happy about it.

Mr. MANSURE. Yes, sir.

Senator MALONE. Thank you very much.

Dr. Flemming, you have been very patient. We are glad to see you. This is the third time you have been before the committee, and you have been very helpful each time. Each time you have helped us clarify the problem we had in mind.

FURTHER STATEMENT OF ARTHUR S. FLEMMING, DIRECTOR, OFFICE OF DEFENSE MOBILIZATION

Senator MALONE. You have heard the testimony of Mr. Hurley of Curtiss-Wright Corp., engine builders, and his estimate of the amount of this material that is needed. You have heard Mr. Mansure of the GSA, and of course you know all about their work, anyway, because at least they are technically under you, as far as their operation is concerned, that is, the extent of their operation.

The particular thing that is bothering the committee, and the reason we felt we might furnish a field of common interest, was that it had come to the chairman from several sources that it is being mentioned, not only around the town but in other places, that all this to-do about titanium was a sort of smokescreen or something, and that we really had an oversupply.

Would you give us a statement to clear this thing up?

TITANIUM ADVISORY COMMITTEE

Dr. FLEMMING. Senator Malone, it seems to me that any statement to the effect that we have a surplus of titanium is just completely and utterly unrealistic, in the light of the testimony that has been given to your committee and in the light of the information that is available to us.

As you know, he last time I appeared before the committee in connection with the titanium matter, I indicated that I was setting up a

Titanium Advisory Committee, and that I had appointed Dr. Herbert H. Kellogg as Chairman of that Committee——

Senator MALONE. Dr. Kellogg, would you come up and sit right here? I think you are part of this picture.

Dr. FLEMMING. I would appreciate it.

Also, that I asked the Assistant Secretary of the Interior, Mr. Felix Wormser, to serve as a member of the committee, and that he had agreed to do so.

In addition to that, we have appointed to the committee Mr. Albert J. Phillips, vice president and director of research of the American Smelting & Refining Co.

As Mr. Mansure has indicated, the General Services Administration has just reached the final negotiation stage on three new contracts for titanium sponge production, with an aggregate capacity of 19,000 tons per year. They have just now submitted those contracts to the Office of Defense Mobilization for consideration.

Senator MALONE. This is an additional 19,000 tons per year for 5 companies?

Dr. FLEMMING. Yes, for three companies.

The Titanium Advisory Committee met last week to consider those contracts, and they have unanimously agreed to recommend to me that I approve the contracts, even though this action results in total titanium sponge capacity of about 32,200 tons per year.

Senator Malone. You had, then, about 13,000 tons under contract?

Dr. FLEMMING. That is correct.

Senator MALONE. And about 2,000 tons actually being manufactured?

Dr. FLEMMING. That is right, two or three thousand.

Senator MALONE. This is annual production, 19,000 tons and 13,000 tons; and 2,000 tons now being produced?

OFFICE OF DEFENSE MOBILIZATION POLICY

Dr. FLEMMING. Right.

I would like to quote for the record, Senator Malone, an extract from the minutes of the Titanium Advisory Committee, because it seems to be that it states a principle that we should adhere to in a very effective way. It is worded this way:

> Titanium metal is now a proven necessity for the design of high-performance military aircraft. As the volume of production is increased and the price reduced, this metal will find new military and civilian used which will cause it to be established as one of the major structural metals for special uses. The present demand for titanium by the aircraft industry is small, but is increasing very rapidly as advances are made in fabricating techniques.
>
> In order to permit the most rapid growth of this new industry, it should be the policy of the Office of Defense Mobilization to keep the capacity for titanium sponge production always one step ahead of the estimated rate of consumption. By thus assuming a moderate surplus of crude titanium, one possible bottleneck in the utilization of titanium is avoided. That means that there will be an incentive for price reduction in a surplus market, and potential users of the metal will be provided with assurance of an adequate supply.

As you know, Mr. Chairman, we have requested the Department of Defense to provide us with requirements for titanium in the event of all-out mobilization or general mobilization. The Department of Defense is working on that assignment at the present time. It is my

hope that not later than sometime during the month of June we will have that information.

Of course, that will put us in an even better position than we have been up to the present time as far as the requirements side of the picture is concerned.

Senator MALONE. I would like to say right at that point, Dr. Flemming, that the testimony in Los Angeles late last year of Don Douglas, of Douglas Aircraft, and Mr. Gross, of Lockheed, and other important manufacturers of planes, was that the earlier testimony of General Metzger on the need for 150,000 tons annually, provided it were known to be available and the plans could be taken off the board and proceeded with at will—they made him look rather conservative, even in peacetime, before they got through, but they did say then that in wartime, actually if a war started—of course, you know people who say the next war will last only a few days or a few weeks or a few months, but we have had those people with us ever since they invented gunpowder, and each time it did not prove to be true.

Dr. FLEMMING. That is right.

Senator MALONE. We have very capable people, and something is invented that offsets it. People stand a lot more abuse than the experts sometimes believe, so nothing ends very soon.

They testified that, of course, it would be a matter of how many planes they needed in actual war, but they put it this way: If the demand on the plane companies equaled or in any way approached the demand in World War II, they would need 700,000 or 800,000 tons per year of titanium production.

We had heard about civilian use, and therefore we thought it advisable to bring in then people who need it and would use it even at the present price in civilian use, because they testified that once they could be assured that it was available so they could take their plans off the board, I do not remember the amount chemical companies said they could use, but it was a tremendous amount of the metal.

Therefore, there seems to be no end to the amount of the metal that would be used, even at the present price. The chemical companies testified that price was no bar to the use of it, although it would be very nice if the price came down.

Then the number of civilian uses will increase, naturally, as the price came down, as it surely will if it follows the line of any prior metal that has come out of our research laboratories. Additional industries will use it, not as a must, but as a moneysaver, I presume.

STOCKPILING

Dr. FLEMMING. Mr. Chairman, one possible use for current production has not been mentioned at all up to the present time. Obviously we have the military requirements which should be met. Then we have the civilian requirements. In view of the critical nature of this particular material, it is certainly one that falls within the definition of strategic and critical materials, and it is certainly one that we ought to think of in terms of a stockpile goal.

Of course, as you know, up to the present time virtually all of it has been utilized, so we have not had any opportunity of putting any in stockpile.

Senator MALONE. I think you have put your finger on a very vital thing, and maybe the answer to this rumor business. Knowing that you are going to need several times or many times what you can produce in the next 2 or 3 or 4 or 5 years, there could easily be an addition to the stockpile of this metal to take the temporary surplus.

Dr. FLEMMING. Surely.

Senator MALONE. Do you intend to make such a recommendation?

Dr. FLEMMING. We intend to set an interim stockpile objective. Then if there is any surplus in current production at any time, we intend to take it and hold it, and it will either then go back in to take care of military requirements and civilian requirements, or ultimately go into the stockpile.

Senator MALONE. You have again proven to me that you are on the job. That is a suggestion that no one has made. They are worrying what they were going to do with it just as they are now holding the sponge. That is the solution, of course.

Dr. FLEMMING. It is the kind of thing that, in the interest of the security of the Nation, we clearly should do if we have the opportunity of doing so.

Senator MALONE. I might ask you the question: In view of all the testimony that you have heard and the information that I know is at your disposal and that you have seen in even greater variety than we have heard before the committee, just how important do you think it is to the defense mobilization, considering the tension building up between the East and the West, as they sometimes call it? I just say if we are getting ready to fight a nation, we should call it by name, and that is Russia and the United States.

SECURITY IMPORTANCE

Dr. FLEMMING. Mr. Chairman, I do not know of any material that is on our stockpile list at the present time that is more important, as far as the security of the Nation is concerned, than this particular material.

Senator MALONE. I am glad to hear you say that.

Dr. FLEMMING. I think we have to approach it in just that way.

Senator MALONE. In other words, now we come to the amount. You have never really limited the amount, according to the testimony of GSA representatives, Mr. Mansure, Mr. Walsh, and Mr. Gumbel. What you are doing is moving just as fast as you think you can bring in new production.

Dr. FLEMMING. That is correct, Mr. Chairman. Whenever they have reached the place where, for example, they have reached in connection with these three contracts, all they need to do is to send them over to us, and I think the extract that I read from the minutes of the Advisory Committee reflects very accurately the spirit of ODM in connection with the proposal.

Senator MALONE. If they look as if in due time they could let contracts for 150,000 tons, as has been testified by everybody as the minimum of our needs, and under conditions with the Government reasonably protected and with companies that have a reputation of doing what they start out to do, you would not stand in the way?

Dr. FLEMMING. Before I made a firm answer to that, of course, I would want to have the Defense Department official requirements figures.

Senator MALONE. Whatever they are.

Dr. FLEMMING. I understand that those figures are going to be available to us by June, and if those figures bear out the kind of testimony that you have had, of course the answer to your question is "yes," because when we know what the defense requirements are, then we are going to do everything that it is humanly possible to do to see to it that those requirements are met, and at the same time we want to do everything we can to build a mobilization base for titanium. So naturally we are anxious to make as much available to the civilian economy as we can so that this material can be built into normal civilian items.

Senator MALONE. Then you do look forward to the time that the civilian economy will absorb enough of it, perhaps in the hundreds of thousands of tons annually, so it would be in the nature of steel—when war comes, you just divert its use.

100 PERCENT ALLOCATION

Dr. FLEMMING. I think that would be the way in which it would work. In other words, we would put it under allocation just as we did steel, copper, and aluminum during World War II and post-Korea.

Of course, as you know, titanium now is 100 percent under allocation, naturally, because of the fact that there is so little of it. It is in connection with those allocation powers which we have under the Defense Production Act that, first of all, we will take care of the military requirements; and then we will do everything we can to see to it that some goes into the civilian economy so we can begin to build and widen our mobilization base; and if by chance there is any left over after that, we would be delighted to put it into the stockpile, because then we would feel much more secure than we do at the present time.

Senator MALONE. I think that is a very sensible solution. I do not believe that you would ever hear anyone criticize it.

Dr. Flemming, this has worried the committee on many materials, not only titanium. For example, in manganese we are getting 800,000 or 900,000 tons yer year from India, and it looks like a deliberate thing. We get our objectives mixed up sometimes. In getting it from India we run two risks: The United States is a long way from India. You are aware, of course, that Mr. Nehru is a very fine man. I spent 4½ hours with him in his own office in New Delhi. He is a very soft-spoken fellow and a mystic, but a great influence over his people. He has taken occasion to say that he is going to be neutral.

His sister, head of the United Nations, has made that statement 2 or 3 times.

A neutral nation might find it advantageous in case of trouble, just to refuse to ship manganese to the United States if we were fighting Russia. If they did not, certainly Russia, right on their doorstep, would find ways and means of destroying and neutralizing the resource.

INDIAN DEPENDENCE

So we are taking two chances: One, India can sort of halfway blackmail us into further agreements or they can refuse to let us have it. We are dependent on them in war and cannot fight a war without manganese, of course, because we cannot make a pound of steel without it. Major DeSeversky testified before this committee you do not make your steel in Pittsburgh; you make it in India. He testified that we are not making our jet engines in Cincinnati; we are making them in Algeria, where we get columbium.

We found columbium in Idaho, but they pay the miners $12 or $14 a day there instead of 50 cents as over in Algeria. We could probably double or treble our production of manganese in the United States under proper principles laid down for foreign trade, and there is probably more manganese in Brazil than the whole hemisphere can use in 100 years.

Now we come to titanium. As you know—and I do not think anyone can properly be criticized—when they started making titanium down in Henderson, Nev., they started getting the rutile from Australia because there was a deposit there which was very handy. Du Pont, over in New Jersey, is getting some of its material, and probably more of it now, from Florida, ilmenite found in the sand. But they do get a lot of the ilmenite from India.

The testimony before this committee, of very fine military strategists, is cumulative that maybe hours after the war starts, this material will not be available to us until we can again control the air over these nations, which might be or could be a considerable time.

Are you taking that fact into consideration in these contracts, and in any way encouraging the use of the ilmenite found in the United States and in southern Canada?

We are informed through our testimony here there is no question about the amount of ilmenite available in Canada, enough to last us 100 years if we learn how to make use of it. Perhaps it could not be put into use immediately a war starts unless we are already using it.

LONG-TERM OBJECTIVES

Dr. FLEMMING. Mr. Chairman, first of all, may I make this general statement relative to the very basic issue that you have raised.

As you know, in the past, in setting stockpile objectives, those who had the responsibility for estimating supply did take into consideration foreign sources, discounting them to a certain extent, but they were still in the picture.

As you also know, by action of the President taken within the period of the last 2 weeks, the Director of ODM has been authorized to establish what are referred to as long-term stockpile objectives. In establishing those long-term stockpile objectives, I have been authorized and directed to discount foreign sources of supply with the exception of those foreign sources where we have ready access from a strategic point of view.

Senator MALONE. The Western Hemisphere, we will say.

Dr. FLEMMING. The exact countries are to be defined later by the National Security Council. The principle is very clear that in setting those long-term stockpile objectives, we are to discount our foreign sources of supply in the event of general mobilization, with the exception of countries that we have ready access to from a strategic point of view. We will certainly apply that basic principle to the area that we are discussing here this morning.

Senator MALONE. In the manufacture of titanium?

Dr. FLEMMING. Right.

Senator MALONE. I want to say to you that I am very gratified at the action that the President took through your committee. You are kind enough to consult with a few of us from time to time, and we have appreciated that fact, and we gave you any helpful suggestions that occurred to us.

Dr. FLEMMING. They were very helpful.

Senator MALONE. Thank you.

With the accent, as you at least indicated, on domestic materials, there is never anything needed to keep mining alive in this country any more than a textile industry or a crockery industry or any other industry, but they do need—and the demand is there and it is necessary—that they be assured, through some kind of principle laid down, that they can get enough more per unit for their product, whether it be a pound of ilmenite or a pound of manganese or a yard of cloth, that adds up to the manufacturer of that cloth the additional price on account of the wages and taxes in this country over the wages and the taxes, efficiency, and other factors that enter into it, in the chief competing nation. That is just about the way the thing adds up.

I have had many people who for 20 years have said we must get the stuff where we can get it the cheapest, where it can be produced the best. They were talking about the cheapest labor.

Of course, some of us do not agree with that. We think that the workingmen of this Nation and the investors in business are entitled to protection equal to that difference in the wages and taxes and various other factors.

I was highly gratified to see your committee recommend taking cognizance of the ability of this country to produce for the stockpiles provided it was properly treated in the way of price. I think it is a fine start.

Dr. FLEMMING. As you know, Mr. Chairman, the problem you have just referred to is a problem which is still under consideration by our Materials Policy Committee.

Senator MALONE. I know that, and I deeply appreciate it. Any information we can furnish you, we certainly will.

It seems to me you have cleared the whole thing up. Do you have any further statement to make?

Dr. FLEMMING. No, I do not, Mr. Chairman.

Senator MALONE. We have Dr. Kellogg with us. He has had nothing to say, and has not been directly called upon, and I do not know that he is ready to talk. You were kind enough to announce his appointment at your last meeting here with us.

Dr. FLEMMING. Mr. Chairman, I might say that Dr. Kellogg and his two colleagues on the committee will be filing an interim report with me very soon, dealing with this whole problem. When I receive that report, we will be very glad to make you acquainted with it and

counsel with you relative to the matters that are raised in the report.

Senator MALONE. We would like very much to look at it, either in confidence, or whatever we could make public would be very good.

I intend to call Dr. Kellogg next.

I am informed that Secretary Talbott is here. I do not expect he has very much to do these days. I know he has been before at least one committee this morning.

Mr. Secretary.

Dr. FLEMMING. I think he just went out, Mr. Chairman.

Senator MALONE. Will someone get him?

Secretary Talbott, Dr. Fleming, Dr. Kellogg, General Metzger, and Mr. Mansure, certainly make up the team who know how to do this job.

While we are waiting to see if Secretary Talbott has gone back to his office, we will ask Dr. Kellogg to take the stand.

STATEMENT OF HERBERT H. KELLOGG, CHAIRMAN, TITANIUM ADVISORY COMMITTEE, OFFICE OF DEFENSE MOBILIZATION

Senator MALONE. Dr. Kellogg, Dr. Flemming was kind enough to announce your appointment at his last appearance before the committee, to be put in charge of the production of titanium and to coordinate its use, production, and all things connected with it, as I understood. You have been kind enough to visit me a couple of times, and we have had very interesting conversations. I know that you have visited the Pacific Coast and the plane manufacturers and some of the plants where this material is being used.

I will not ask you any specific question that would embarrass you at all, but if you have something you could offer to the committee about what you have learned and the inspections you have made, that would be very interesting and helpful in the record.

First, Dr. Kellogg, will you identify yourself for the record?

Professor KELLOGG. I am Herbert H. Kellogg, chairman of the Titanium Advisory Committee of the Office of Defense Mobilization.

Senator MALONE. Your former connection?

Professor KELLOGG. My not former but still present connection is on leave from Columbia University.

Senator MALONE. Go ahead.

Professor KELLOGG. I found the assignment that Dr. Flemming gave me intensely interesting. It is really a fascinating experience to go into these aircraft and engine plants and see how they are using this new metal and how they are meeting the innumerable problems that arise in the utilization of a new material like this. The enthusiasm which they have for the job that is cut out for them is really tremendous, and it certainly gives me the feeling that those men and the country in general are right in supporting the rapid growth of the titanium industry.

PRODUCTION POLICY

As far as my actual committee activities are concerned, we have held only the one meeting that Dr. Flemming referred to, and I want to say that my entire committee was strongly behind the idea that we enunciated in the excerpt from the minutes which Dr. Flemming read; namely, that we are in support of a policy which will keep pro-

duction fully one step ahead of foreseeable demand, and also in support of a policy which will create a moderately large inventory of titanium available so that sudden spurts in demand can be taken into account.

For the record I should like to clear up a couple of points about which I think there was some mistake made this morning.

The capacity of this country to produce titanium this year is about 5,075 tons estimated, not 2,000. I think it is important to let the country know just what our potential is, so that an engine manufacturer or an airframe manufacturer who wants to use it will not be scared by thinking it is only 2,000 tons.

Senator MALONE. You mean by that that it may have been 2,000 last year and at the present moment it may be around 2,000, but the increase will make it up to 5,000 tons?

Professor KELLOGG. That is right. During 1954 it is expected to produce about 5,000 tons of titanium sponge. Also, the estimated inventory at the end of 1954, based on foreseen orders, will be about 3,000 tons. We consider this to be a fairly healthy beginning of an inventory and one which, again, we hope will give confidence to the users of titanium that they can at least make a moderate increase in their present demands.

Senator MALONE. You agree, then, with the testimony of Dr. Flemming and Mr. Mansure that what you are trying to do is to create that going-concern production, coupled with any stockpile or inventory that you might have, so that the engine companies and the plane builders and later civilian industry can slowly go into use and have confidence that it will be available without having to change their setup again right in the middle of production.

Professor KELLOGG. That is right.

Senator MALONE. Dr. Kellogg, it is not necessary for me to tell you, for you are an engineer and you know as well as I do that there never has been a problem—we can brag a little—that the engineers and scientists did not whip if it was necessary and if they had the money with which to do it. It was aluminum first, and there have been many other metals. It happens to be titanium now. We are in the uranium nuclear power business, and that is just another branch for the engineers and scientists. This problem will be whipped. We will whip the problems of nuclear power just as surely as we live. It is just a matter of time and the pressure that is on them. You agree with the way enginneers and scientists operate.

Professor KELLOGG. Yes.

WILL MEET PROBLEMS

Senator MALONE. Do you have any misgivings as to the ability of the potential producers, producers, and the engineers and scientists in the laboratory to whip this problem within a reasonable time if the interest is there to have it done?

Professor KELLOGG. I am certain they can handle the problem as you suggest they can. It would be very hard to make an estimate of just how long it will take to whip certain parts of the problem, but that there will be steady progress toward more efficient utilization and more efficient production of titanium I think there is no question.

Senator MALONE. I doubt if we added up year by year the anticipated production from the contracts that you have now let and the ones that you have in prospect, if you say you can manufacture 5,075 tons this year on the increase in production of the people who are already in production and who will come into production this year—does that include more than the two companies, some production from a third one?

Professor KELLOGG. It includes a little bit from the Bureau of Mines and a little bit from Dow Chemical Co. I think those are the only 2 besides the major 2.

Senator MALONE. By the way, are they not putting the Bureau of Mines out of business now?

Professor KELLOGG. At least the scale of operations will be reduced in the latter part of this year. I am not positive what arrangements have been made.

Senator MALONE. I heard some rumor, and I was going to ask Felix Wormser about it. You no doubt have all the details. I heard that they were wrecking that plant down there and selling it. It did not seem to me to make much sense to do that until there was enough production elsewhere or at least in sight.

Professor KELLOGG. I really do not know what the latest decision has been. When I was down at the Bureau over a month ago they were still discussing what should be done with it. They were not too anxious, as I understand, to continue as a producing unit because they feel that, after all, they are a research and development unit, not a producing unit. But if ODM and GSA felt it was essential that they continue, they were perfectly willing to continue.

CIVILIAN NEEDS

Senator MALONE. I asked the question if their production of 1 ton per day interfered with their scientific investigation and laboratory work, and we were assured at that time that it did not. That is all we were concerned with.

Have you had any time to make an estimate or summation of the civilian situation? Do you agree that there is a civilian industry ahead of us in the production of titanium?

Professor KELLOGG. I think there is certainly one ahead of us. I am not certain that it is here right this minute.

Senator MALONE. It is not here just this minute because you do not have the titanium.

Professor KELLOGG. Because we don't have the titanium. I might mention in that connection that the Industry Advisory Committee for Titanium Producers and Fabricators, something to that effect, of the Business Defense Services Administration of the Department of Commerce, met early in March and recommended that a civilian allocation of this material of somewhere between 10 and 25 percent be made at this time in order that the smelters and fabricators of titanium could go out and seek limited civilian markets with the assurance that they would have some metal to meet the demand. I think that is a healthy step in the right direction. The order is not yet official, I believe it is under consideration.

Senator MALONE. You would not want to allocate too much of it to civilian use until you had a backlog, a stockpile, and a going concern industry to take care of the national defense needs, would you?

Professor KELLOGG. No.

Senator MALONE. But coordinated with the national defense needs, I think it is a constructive suggestion.

You are aware of the testimony of the chemical companies that they need it very badly in the chemical industry even at the present price.

Professor KELLOGG. I read that testimony; yes.

Senator MALONE. A very responsible company presented that testimony, so I did not question it.

Professor KELLOGG. I dare say if they presented an order to one of the fabricators, they might have it accepted rather promptly at the present moment.

Senator MALONE. Now let us go into that. I was rather assured by Dr. Flemming's testimony that they were going to take care of the backlog and stockpile until they had reached a rate of production so that the airplane manufacturers and engine makers could go to work and use the material. If we start allocating it, allowing them to get contracts for chemical use and chemical industries, they will become dependent upon it and that will delay the time that these people can use the parts.

Professor KELLOGG. I think you are right. I think the chemical industry would be unwise to ask for any large, steady use of the material now.

Senator MALONE. Would you not be unwise to allocate it to them?

Professor KELLOGG. Yes; I believe so.

Senator MALONE. You would agree with that?

FIRST CALL FOR MILITARY

Dr. FLEMMING. Just where that point is, Mr. Chairman, is always difficult to figure out. Certainly we must not make any allocations that would in the immediate future, or in the long term as far as that is concerned, put the military in a difficult situation, because they have to have first call on the current consumption. If there is any possibility, for example, of their stepping their requirements up in the fourth quarter of this year or in the first quarter of next year, and so on we have to know that and we have to take that into consideration, and instead of letting all the current production go out either to military or civilian use, we will have to hold some of it back so we will be in a position to take care of their increased demand.

Senator MALONE. In any case, you would not make such an allocation without close cooperation with the Army, the Air Force, and the Navy.

Dr. FLEMMING. That is right. There is no question about it.

Senator MALONE. It does seem that it might be advantageous to allocate a certain amount for experimentation and laboratory work so they would know what they could do with it when it was available. It would not amount to anything in quantity.

Dr. FLEMMING. Mr. Chairman, my understanding is that the Department of Defense is interested in the possibility of our making some allocation for civilian use because they recognize that as we do that we strengthen our mobilization base; we broaden it. Clearly that is one

factor that we should take into consideration from the security point of view.

Senator MALONE. I think that is absolutely correct, but you would have to do it as you get ahead of the demand for the engine and the plane makers.

Dr. FLEMMING. That is right.

Senator MALONE. When I get out of my field, I want it understood that I am not speaking with any authority. Maybe that is not true, but it is a suggestion, and if you agree with it and if General Metzger does, perhaps it is true.

Dr. Kellogg, you have visited several plants, including the plane manufacturers and the users of titanium in Pittsburgh and elsewhere; have you not?

Professor KELLOGG. I have visited a number. I have not covered the field very completely; no.

Senator MALONE. Probably a person would not need to cover all of it. I think you took the proper course in getting a perspective.

Professor KELLOGG. I have found it extremely valuable to me, Senator, and I intend to continue visiting and finding out what I can in the future.

RAPID GROWTH EXPECTED

Senator MALONE. Do you agree with Dr. Flemming—we consider him the last word since he is the chairman of the committee and the father of your committee—that you do need a tremendous amount of titanium; more than you are likely to be able to produce this year and next year; that you have a considerable way to go before you reach the point of a going concern production and stockpile or inventory so they can slowly begin to put these things into permanent production?

Professor KELLOGG. We certainly do. That is, the industry is going to continue to grow rapidly for some time. It is far from leveling off, I would say.

Senator MALONE. You are familiar with the testimony that we need 150,000 tons a year right at the moment if they could be assured that when they take these planes and engines off the drafting board, they would not have to back up. I do not know how far you have studied this evidence, but do you agree that there is a tremendous demand for it if you have it and can make it available on a steady basis, without any slack or change in their program?

Professor KELLOGG. I think you are right. The way you state your question makes it a little difficult to answer exactly.

Senator MALONE. You answer it in your own way. I am interested in your answer.

Professor KELLOGG. It wouldn't surprise me to see the titanium industry grow to the order of magnitude of 150,000 tons a year within, shall we say, 5 or 10 years. I would not want to say how long.

Senator MALONE. It had better be under 10 years.

Professor KELLOGG. It should probably be under 10 years, yes.

Senator MALONE. Or else——

Professor KELLOGG. When you ask me to answer whether we could use 150,000 tons this year if we had it, I don't know the answer to that question because we don't have it, so we can't tell whether we could use that much.

Senator MALONE. You are not supposed to know that of your own knowledge, but you are supposed to find out. You were up there where they knew. Did you ask them?

Professor KELLOGG. Not that question, no.

Senator MALONE. Maybe you ought to write to them. They told me they could. If you are not convinced, I think you had better go into it further.

Professor KELLOGG. I don't want to leave an incorrect impression in your mind. I am firmly behind the idea that we must expand the titanium industry just as rapidly as the military or the aircraft-engine manufacturers can use up the material.

Senator MALONE. I do not think you can do that. Do you think you can? You are away behind.

Professor KELLOGG. We may be a little behind now. I think we can catch up very quickly.

Senator MALONE. How quickly?

TWO-YEAR LAG

Professor KELLOGG. The evidence points to the fact that new production can be gotten underway 2 years after signing a contract, and I think therefore that the maximum lag that we would have behind requirements is 2 years. In 2 years we should be up to date, provided we get from the Defense Department a good estimate of what requirements will be 2 years hence.

Senator MALONE. When do you expect to get this estimate that you can depend on?

Professor KELLOGG. We expect it to be available to us in June, according to the latest report.

Dr. FLEMMING. That is what I indicated, Mr. Chairman. The Defense Department tells us we should have it in June. That is their all-out mobilization requirements. That would be their estimate of what their all-out mobilization requirements should be.

Senator MALONE. That is 3 months. Do you have any confidence in the testimony you heard this morning from Mr. Hurley that the engine companies could use a tremendous amount of it that is not available now, that piece by piece they can put it into their operation?

Professor KELLOGG. I certainly have every confidence in his testimony.

Senator MALONE. Do you have any confidence in the testimony of the plane builders that they can do the same thing?

Professor KELLOGG. I do.

Senator MALONE. You are not waiting, then, to let any contracts until you get this thing through?

Professor KELLOGG. No.

Senator MALONE. If you are, we had better have these boys down again this week.

Dr. FLEMMING. Mr. Chairman, in setting the expansion goal, which means evaluating your requirements over against the supply, we always take into consideration not only the military requirements but also the defense-supporting and war-supporting civilian requirements, and so on. Certainly all of the evidence that you have taken from prospective users of titanium will be very helpful to us and very valuable to us and will be considered by us in setting any ultimate

expansion goal. But I think you appreciate the fact that we do need as a starting point the military requirement on all-out mobilization. In the meantime, while we are waiting for that, if Mr. Mansure comes in with another contract that rests on a good, solid basis, we will say, "Go ahead." In other words, this is an area where I feel you can take a calculated risk, and it isn't very much of a risk.

Senator MALONE. We intend to call for the next witness a man who knows exactly what they can use, and if he says they can use as much as he said before they could use if you could produce it, do you still doubt it?

Dr. FLEMMING. Senator, I think General Metzger would agree finally that the Department of Defense has to transmit to us a statement as to their requirements, which will be not only Air Force requirements but also the requirements on the part of the other services.

Senator MALONE. You are not holding back waiting for that.

Dr. FLEMMING. No. It is clear from what Mr. Mansure says that they have three contracts that they are ready to sign, which bring us up to 31,000 or 32,000, and we will say, "O. K., go ahead and sign them. Let's move."

Senator MALONE. Suppose he came in with 50,000.

Dr. FLEMMING. I suspect that is a rather hypothetical question in the light of what I know about the situation and what I have been told about the situation; but if he came in with that, I would say to Defense, "Wait a minute. We can't wait for a refined set of requirements. Give us your very best judgment as of the present time so we can make an immediate decision."

Senator MALONE. Maybe we ought to get that next week. I detect a sort of hesitancy on the part of Dr. Kellogg to go ahead until he has that final estimate, and he is not yet convinced.

NEED DEFENSE GOAL

Dr. FLEMMING. Senator, I think the policy of ODM on that is just exactly what I have said. We are not going to set a final expansion goal until we get the requirements from the Department of Defense. We follow that, as you know, in connection with every metal and every material. At the same time, when you are dealing with a rapidly developing situation, if you haven't what you would consider to be the best evidence, you take what evidence is available and you arrive at a decision.

In the light of the information that has been made available to us, I don't have any hesitancy in my own mind in encouraging GSA to go out and negotiate contracts wherever they can. I don't have any hesitancy in my own mind in deciding to approve those contracts when they are negotiated.

I will feel better about the whole thing when the Department of Defense finally comes through with their all-out mobilization requirements, because then we will have a little better evidence than possibly we have at the present time. As you appreciate, materials requirements of the Department of Defense depend of course upon certain strategic decisions as to what their mobilization planning is going to be. As you know, there have been some changes in that over a period of the past few months. Naturally, after they have gone through that process and have translated it into materials require-

ments, then we rest on a firmer foundation, whether it is titanium or aluminum or copper or any of the other materials that we are interested in.

Senator MALONE. For 20 years we have steadily helped the United States to run out of the production of the materials that you are talking about. There is not any question about it. The policy of the National Government has been to decrease the production. Some of us are tired of it.

Dr. FLEMMING. As you know, Mr. Chairman, the policy of this administration is the reverse, as reflected by the President's directive.

Senator MALONE. I hope so; but there are a lot of things that enter into production, such as the confidence of investors in the production of these materials, which have not changed much yet.

Dr. FLEMMING. I know the issue to which you refer, and the one that you refer to——

Senator MALONE. It is a tough issue.

ENCOURAGE DOMESTIC PRODUCTION

Dr. FLEMMING. That is right. As you know, the Materials Policy Committee, of which Secretary McKay is Chairman, is going into that. We are going to make some recommendations in that area also. But, again, I think that the new stockpile policy reflects very clearly what the basic motivation of this administration is, namely, to encourage the development of our own resources and to utilize what we have.

Senator MALONE. Yes; and to forget this idea that you are running out of materials in this country. The only way you can possibly run out is to make it unprofitable. That is what they have done for 20 years, and then come along with a subsidy or something as a bait on the end of a stick, which can be removed at any time by the word of an official. You are not going to get these materials by just fooling along with it and keeping a little bait out there. You are going to have to set down a policy which investors can depend upon. There is not any question about that.

Dr. FLEMMING. I agree with you.

Senator MALONE. You have contributed very much to the hearing this morning when you say that this temporary overproduction which exists, until Mr. Hurley and his associates can start using it with some confidence, you are going to recommend putting in the stockpile.

Senator MALONE. I had this hearing this morning to clear up that one point, that you have a surplus. It is all over Washington.

Dr. FLEMMING. Mr. Chairman, let me make it perfectly clear, because this is a policy responsibility on the part of the Director of ODM: We are not holding back. We will not set a firm expansion goal until we get the military requirements from the Department of Defense. In the meantime we are going to move just as I have indicated.

Senator MALONE. But you would not limit any contracts that you could possibly get now which looked as if they were fair to the Government, until you were somewhere near the testimony of the makers

of the planes and engines and the men who know exactly what we do need.

Dr. FLEMMING. The answer is that we would not.

Senator MALONE. That is all. Then I don't think we will have to call any more hearings next week.

Dr. Kellogg, you did not tell us anything about what you saw. Maybe you do not wish to. But you did visit these various places.

Professor KELLOGG. I did.

Senator MALONE. How long—I do not think I need to ask this question because the chairman of the principal committee has answered that you would not hold back on any reasonable contract that you could get within the limit of the testimony we have now, and that is 150,000 tons; but if you did have to call Mr. Wilson, if we had to get him before this committee, or if you had to get him down to the White House, it would hurry up that estimate, would it not?

Dr. FLEMMING. That is right. Furthermore, we would get complete cooperation.

Senator MALONE. Of course you would. He was before our committee. I know that. He is a wonderful fellow.

Dr. FLEMMING. That is right.

Senator MALONE. I think that is a terrific thing. That is the kind of thing that makes progress.

TO USE DPA FUNDS

Dr. FLEMMING. Actually, Mr. Chairman, this is what we will do: We will use Defense Production Act funds to acquire the material. We will hold it. In the meantime we will set an interim stockpile objective. Then we will just hold it and decide at a later time whether it should actually go into the stockpile—of course, you know that when it gets there it is pretty well insulated—or whether it should actually be allocated for civilian and military use. The mere fact that in the month of June or the month of May the military requirement plus the civilian requirement just does not happen to be enough to take care of the current production is certainly no excuse whatever for anybody's saying that we have a surplus. As you take the long-term look, it is clear that it is not at all a surplus.

Senator MALONE. It is a shortage, not a surplus.

Dr. FLEMMING. It is one of those vicious circles that we have to break through. The Government is in a position to break through it by the utilization of Defense Production Act funds. That is why we have that revolving fund of $2,100 million. That is what we intend to do, to break through and take all that is available. Some of it we may hold. If there isn't a sufficient demand for it in any one month, we will hold it and allocate it later on.

Senator MALONE. I come back to this one thing: I shall call a hearing next week and ask Secretary Talbott and, if necessary, Secretary Wilson down here if you are holding back waiting for this information.

Professor KELLOGG. We aren't holding back.

Dr. FLEMING. There is no question about that at all.

Senator MALONE. We are lucky to have him in there.

DESIRE TO COOPERATE

In our report which we will present to the Senate committee and to the Senate, what we want to do is to be helpful to you. There are 5 of us on this subcommittee; there are 13 on the Interior and Insular Affairs Committee. I am sure that you will have the cooperation of all of them if we could just go in there with information that is not knotted up some place. They have considerable to do with giving you the money to do it with, and I am sure there will be no difficulty. We have had a great experience in this subcommittee, I believe because in our operations since we started hearings in September we have never yet been crosswise with a Cabinet officer or the head of an agency. We have had full cooperation, and I hope we are giving it. We have no place in the picture that I can see under the Senate resolution except to be helpful in bringing about the thing that Congress is worried about, and that is that in case of war we find ourselves dependent on some area where we cannot get it. Certainly the evidence points that you cannot get it from India or from Australia.

That is the reason I was so particular in asking the question, which was answered in the affirmative, that you are making arrangements to make ilmenite in this country, or rutile if you find it in the United States, or in Canada where it is estimated that the Kennecott Copper Co., has a mountain of it. We have information that there are other mountains of it. It is just a question of developing it. It is available.

I want to point out again that for 20 years some of us sweat blood both for the national domestic economy and for the national defense of this country against the policy of making us dependent on nations across one or both major oceans for things without which we could not fight a war and without which we could not run the civilian economy. I am aware of all the arguments that you must do this and that, but I live in America and I am interested in the defense of America. Whatever we have to do to do that, you will find me in there helping you, but you are not going to find me in there helping you in spreading this thing out all over the world so you cannot handle it in wartime and you cannot handle it without being blackmailed into agreements that you do not want to sign because you are dependent in peacetime for something that you cannot do without. I am tired of that. I hope when we get this report to the Senate floor, that will be clear.

I certainly appreciate the appearance of you men this morning. We now want to hear General Metzger to sum up this information. He has done it for us a couple of times. The general is right in the middle of it.

Will you take Dr. Kellogg's place there, General Metzger? We will not ask you gentlement to remain unless you want to hear the testimony. I know you are busy.

The general has been very helpful to this committee. In the first place, we have the habit of going to places where the information is to get it, and then getting all of the ideas that we can get and cordinating them. The general is right in the middle of it at Wright Field. He is in the Air Materiel Command, Wright-Patterson Air Force Base. I will not even estimate the number of times that I have called on him. Practically every hearing had to do with materials which he is using.

General, you have heard the testimony this morning. I have expressed to you that I was perturbed about information we were receiving that there was some kind of vacuum in this thing. If you will in your own way sum this thing up for us this morning, how you can best put it to use and how we can cooperate with the people who have in their hands the contracts to be let, the committee will be very appreciative. We impose on your time considerably, but we think it will be helpful to us.

FURTHER STATEMENT OF MAJ. GEN. KERN D. METZGER, AIR MATERIEL COMMAND, WRIGHT-PATTERSON AIR FORCE BASE

General METZGER. Mr. Chairman, I fear that many of my remarks this morning will be repetitious of the excellent and learned statements made by other witnesses. However, I would like to say that titanium possesses the most favorable strength-weight ratio of any material known to the aeronautical industry today within a temperature range of 300 degrees and 800 degrees Fahrenheit.

Mr. Hurley, of Curtiss-Wright, explained, I think in excellent manner, the fact that the airpower of this country requires superior air weapons for the security of the country. Greater power means higher temperatures. Greater speed generates higher temperatures.

In view of the great weight-saving possibilities through the use of titanium, the demand for titanium is self-established.

DETERRENTS LISTED

There are at present four deterrents to the increased use and application of titanium in aircraft and aeronautical products.

First, I class the quality of the material presently being produced and the alloys in which titanium is presently being produced. The quality has not been uniform in unalloyed form, and the alloys themselves have not been either uniform or satisfactory to the ultimate use for which the material is required. For example, we do not today have in production a weldable titanium alloy.

However, the question of quality and alloying is one which is common to the growth of any new material. Great improvements have been made in quality and many alloying programs are in effect today which, without question, over a period of the next several years or few years will provide industry with the alloy material presently desirable.

The second deterrent to increased use at present, as we see it, is processing and fabricating know-how. The aeronautical industry is confronted with the problem which is common to the use and development of any new material, of learning how to use it. When one stops to realize that in aircraft particularly, engines and airframes themselves, an exhaustive qualification test must be given to every part produced with titanium in order to assure safety in flight or approval for continued use in production, one can well realize that it is time consuming and costly.

The third of the deterrents I would class as limited supply. That has been covered very ably by Dr. Flemming and by the chairman himself. Very obviously, we may not permit titanium to be committed unalterably in the design of our aeronautical products unless we are assured that the supply will be available to support the pro-

duction schedules of those products to which the titanium is committed.

LOGISTICS PROBLEM

Senator MALONE. There are many reasons for that, are there not, General? One might be interchangeable parts for an airplane which you had to ship overseas. If you had a group of airplanes overseas and had to quit manufacturing these particular parts, you might suddenly find yourself out on a limb that you could not get back from.

General METZGER. That is true, Senator Malone. The logistics problem would be a very severe one and difficult to live with, but even beyond that, interchangeability in aircraft between materials is a hazardous situation and must be avoided whenever possible.

It is not a responsibility of the Air Force alone to approve the use of an application of titanium in its products. It is also a responsibility of industry. Our manufacturers may well accept that responsibility, and they are certainly aware of it.

Senator MALONE. When you send a certain number of airplanes overseas, do you not try to ship enough spare parts at the time or have them going over there, so there is no chance for their going out of active use for lack of spare parts? How do you arrange that part of it?

General METZGER. Mr. Chairman, spare parts for aircraft engines or equipment are delivered concurrently with the end item itself, and in sufficient quantity to provision the aircraft for a particular program.

Senator MALONE. In other words, unless you had enough titanium to make these additional spare parts as well as to create the plane in the beginning, you just would not dare to start using it, would you?

General METZGER. That is correct, we would not.

Senator MALONE. So that comes back to the point that there may be temporarily some material that they are preparing to stockpile and inventory. I think that is a fine suggestion that Dr. Flemming has made, and this is the first time anybody has mentioned it, not because we did not think it was necessary, but I guess we just did not think about it. They are preparing to stockpile and inventory this material until the going concern production and the inventory equals in their judgment, or in the judgment of whoever is in charge of that particular use, an amount which would justify taking a chance. Is that about it?

General METZGER. That is it as I understand it, Mr. Chairman.

NO OVERPRODUCTION

Senator MALONE. In your judgment has there ever been any overproduction of titanium? You have heard that rumor, as I call it. It was a little worse than a rumor for a while. It was said that the committee had gone out on a limb and that we had too much titanium already, more than we knew what to do with. I asked one of them who gave me the report, "Where is it?" They said, "Du Pont is trying to sell it, is looking for orders." What do you think about that situation?

General METZGER. I believe the situation is most certainly a temporary one——

Senator MALONE. But caused by the fact that there is not enough titanium. It is really a shortage, not overproduction, because you do not dare start using it. Is that not right?

General METZGER. That is correct, sir. That is my opinion.

Senator MALONE. Then what is all this about? If you ever pick up another rumor like that, I hope you phone me immediately, because the next hearing we have on it is going to be really good.

General METZGER. The problem of keeping demand in balance with supply——

Senator MALONE. Next time I think we will go into the organizations.

General METZGER. In a new material in the growth and development stage, if I may continue my statement——

Senator MALONE. Yes. I am sorry I interrupted you, but I wanted to emphasize that one point.

General METZGER. Is one which cannot be accomplished to perfection, and in our approval and use of titanium in military products, aircraft, we will undoubtedly scale our demand below the availability of the material at the moment. I am sure that has been recognized by Dr. Flemming, and Dr. Kellogg's committee have recognized that that will be the situation and have taken steps to keep one step ahead of our demand.

Senator MALONE. May I ask a question at this point, General, to clarify it? I do not want to interrupt your trend of thought, because you are just the kind of witness the committee likes to have, but is it not expensive to tool up for a new part of an engine and then expensive and awkward to tool back? In other words, do you dare tool up and start using a part that you think would be unavailable practically at any time?

General METZGER. No; that we must not do under any considerations.

Senator MALONE. It is a very expensive thing, is it not?

General METZGER. It is very expensive.

Senator MALONE. And dangerous?

DESIGN REPRODUCIBILITY ESSENTIAL

General METZGER. And beyond the immediate expense of it, it makes our production unreliable. Reliability of production, the reproducibility of design of our products, is essential in the development of our Air Force.

Senator MALONE. Then are we not just in the stage of using titanium in planes, the frame and the engine, and even in civilian use as testified here by the chemical companies, just like a man going out in the middle of timber to build a house? He first has to get the logs. Until he can find and strip and prepare enough logs, he cannot start to build the house, can he?

General METZGER. Not very well.

Senator MALONE. He may have a pile of logs over there, an overproduction at the moment if someone came along not knowing anything about how to build a house. Is that not true?

General METZGER. That is correct.

Senator MALONE. He would say he has too many logs, but in a few hours after he starts building the house he is short of logs, and that is the reason he has not started yet. Is that about it?

General METZGER. That is correct, sir. It is a very good analysis of the situation.

Senator MALONE. I hope this thing does not come up again, but if it does, we will handle it, with your help.

Go ahead.

COST FEATURE

General METZGER. The fourth deterrent to increased use, as I see it, is cost. One could place that particular consideration, cost, in a different sequence here. Cost in the production of our aircraft is certainly highly important. The cost of titanium today, as was touched upon by Mr. Hurley very well, is such that we must weigh very carefully the use of titanium and its military advantage, its advantage in the application or in the aircraft or in the engine for which we are considering it.

Senator MALONE. In other words, you might not use it in a freight plane in the United States, but you would use it in a plane that you wanted for long-range use, carrying bombs or material or soldiers in an important area, or for use in your fighters. Is that what you mean?

General METZGER. That is correct in part, but even a little beyond that: We would not approve the use of titanium to achieve a weight saving of 10 pounds at a cost of several thousand dollars where that 10 pounds would have no particular significance in the performance of the aircraft. As the cost of titanium is reduced, as it undoubtedly will be—it must go through the normal pattern of other materials—our range of consideration——

Senator MALONE. If it came down to a cost of, say, a dollar a pound, it would displace nearly everything else, probably.

WOULD REPLACE STEEL

General METZGER. Should it reach the cost of steel or approximate the cost of steel, there is no question that where the application and the temperature and the strength properties would justify and permit its use, it would replace steel, because it is lighter.

Senator MALONE. We have the testimony of the plane makers and the engine makers, as we have heard from Mr. Hurley here today—I did not think it was necessary to have all of the engine makers because their demands would be about the same, at least for the same purpose—that the use in long-range bombers and fighters for sonic speeds would add up, if it were available, to putting 25 to 40 percent titanium in one of these long-range plans. Later, as you say, it might increase, but not at the moment. We have the testimony in Los Angeles that 150,000 tons a year, if you could go right ahead and not look back, just like steel, knowing it would be available, would be needed. Are you still of that opinion?

General METZGER. Yes, sir, I am of that opinion. If progress continues in improving the quality and in alloying the material to improve its physical and other characteristics, I am still of that opinion.

Senator MALONE. Is there any doubt in your mind, the demand

being there and the material being available, that progress will be made?

General METZGER. I am personally convinced that progress will be made.

Senator MALONE. How would it be made? It would not be made unless you determined to use it if it were available, would it?

General METZGER. That is correst, sir.

Senator MALONE. People are not going to expend money in laboratories to produce an alloy, spending perhaps hundreds of thousands of dollars to produce something that you would not use if they had it.

TITANIUM SET BACK

General METZGER. That is correct, sir, and there is no question, I think we all generally know, that there has been a setback in the use of titanium in the aeronautical industry.

Senator MALONE. Why?

General METZGER. No. 1, the material as furnished was of unsatisfactory quality.

Senator MALONE. You are talking about the hardness now, among other things?

General METZGER. Hardness, inclusions in the stock, in the material itself, and lack of uniformity between one wrought shape and another designed for the same purpose.

Senator MALONE. That makes it more difficult to incorporate in your construction, or to work.

General METZGER. To work is correct. That is one setback. No. 2——

Senator MALONE. Before we leave that one, we had the representatives here of the steel companies that are machining and getting ready to use this material, and they said they were going to whip those problems; did they not?

General METZGER. That is right.

Senator MALONE. They did not hesitate. That was Republic Steel. I do not recall the others.

General METZGER. Mallory, Sharon. I believe they all testified to that and, without question, as I mentioned a few moments ago——

Senator MALONE. If I sized up the type of men who were giving the testimony, I think they are going to do it.

General METZGER. I am sure they are, and I think they are making great progress, as I mentioned a good bit ago.

Senator MALONE. They are going to do it if the head of national defense, the head of ODM, and the people who are buying these planes from them which contain these parts furnish a steady demand.

I thought I had run it down to the end. In every paper you pick up we are quarreling a little more with somebody. Sometimes we are going to do away with the use of something because it is too dangerous. Personally, having seen 2 of these wars and been in 1 of them, I would rather fight with an atom bomb in a plane than with a bowie knife. I am afraid of a knife myself. Just confining it to knives, I would not go for that. Let us use what we have. Maybe that is the way we can prevent a war. Is a bomb any good unless you can deliver it?

General METZGER. No, I wouldn't think it would be of much value.

Senator MALONE. Do you think you can deliver it without the material you are talking about and the speed you are trying to reach, 700 or 800 or 900 miles an hour? Do you think you can deliver it with a slow plane?

General METZGER. I should say it would be very doubtful.

Senator MALONE. There would be some danger to the pilot, too, would there not?

General METZGER. I think so.

Senator MALONE. It costs a good deal of money to train him, to say nothing of the insurance he carries which it would cost you if you killed him, and to say nothing of his folks and maybe his wife.

General METZGER. That is true.

Senator MALONE. We do not like to kill them. Would this not help to save their lives?

General METZGER. It will provide a better aircraft for him to fly.

Senator MALONE. If you could outfly an enemy aircraft it seems to me I remember that was quite an item in the wars I have seen. Is it not?

General METZGER. Yes, it is always an item.

Senator MALONE. Then what are we talking about? What is the roadblock?

PROBLEM OF ALLOYS

General METZGER. Senator Malone, as I mentioned, there are four deterrents. We were just discussing the temporary setback. That setback, first of all, was brought about by poor quality and lack of proper alloys, both of which are programed to be cured and will be cured, I am sure.

Senator MALONE. I sat there and listened to Don Douglas and Bob Gross, and my heart went out to them. They work hard. They work 18 hours a day. They have thousands of men working for them. You have to take only one look at those men to know that they can build anything that they tell you they can build. Aren't you convinced of that?

General METZGER. I certainly am.

Senator MALONE. I heard them say this was a "must."

General METZGER. I have heard that from them many times.

Senator MALONE. Why would they say that if they had any doubt that they could use it?

General METZGER. I am sure they would not.

Senator MALONE. Do you have any doubt that they will know how to use it and how to prepare these alloys, they and the people working with them, if they have it of the proper hardness and quality? Do you have any doubt of it?

General METZGER. I have no doubt whatsoever.

Senator MALONE. Does anybody you know have any doubt of it, who has any information and who knows anything about this business?

General METZGER. I haven't spoken with anyone who indicated a doubt.

Senator MALONE. The only ones that I see who have any doubt about it are the ones who know nothing about it. I just know enough about it, after listening for 4 or 5 months, to perhaps separate the wheat

from the chaff, I hope. When little people—and I am convinced that is where these rumors come from—build up a kind of area of expertness that they cover, they are authorities because no one else knows what they are doing or no one else knows any more about it. They sort of take over. If it gets out of their hands, if there is too much knowledge, they are no longer experts. If this thing becomes as common as aluminum—and I am convinced that it will in 10 years—we will no longer need an expert like that who does not know of his own knowledge how to use it. Is that not true?

General METZGER. That is correct.

Senator MALONE. Is it not time we dug this thing out now, wherever the logs are jammed, and get to work on it just along the lines Dr. Flemming testified to?

DELIVERY DELAYS

General METZGER. Senator Malone, I believe that we have pretty well done that. I am sure the people are working on it in an aggressive and intelligent manner.

The other setback was one of failure on the part of the producers of titanium to deliver in accordance with their delivery promises. Supply I think is the only big problem today which perhaps is the responsibility of any Government agency. I for one am satisfied that Dr. Flemming and Mr. Mansure have that well in hand and are pursuing it in an aggressive and intelligent manner.

Senator MALONE. Are you familiar with the report that the national defense organization is going to make to Dr. Flemming about the demand?

General METZGER. I am not familiar with it, Mr. Chairman. You mean the Department of Defense requirements?

Senator MALONE. Yes.

General METZGER. Yes, sir; I am familiar with that because I am responsible for the requirements to be presented by the Air Force.

Senator MALONE. Then I have no doubt they will take your advice where they are headed. I do not think Dr. Flemming has much doubt about it, either.

I do not want to embarrass Mr. Hurley, but I want to mention that we heard General Electric, Fairchild, Republic, General Motors, Westinghouse, and others, as well as Mr. Hurley of Curtiss-Wright. Those men sat before this committee and poured their hearts out as to what they needed because they had, I think and I hope, confidence enough in the committee that they were not going to be embarrassed and that this committee wanted to be helpful. The head of each of those companies who came before the committee looked to me as if he knew his business. They were beyond me on the technicalities, but I have seen thousands of engineers and scientists in my 30 years in the engineering business and I am convinced—and I want to know if you are—without embarrassing Mr. Hurley, that he can do what he says he can do when he says he can do something in building an engine to go in a plane. Do you think he can do what he has in these specifications?

General METZGER. I am convinced. He has built some mighty good engines.

Senator MALONE. Do you think he can do what he says he can do, that he can take it part by part as he laid it out in the specifications, and adopt the ones that you think are more important as the titanium

becomes available, and put it in the plane permanently from there on? Do you think he can do that?

General METZGER. I think he certainly can do it. He has qualification tested many of the items he has covered by photograph in this study. Others he must test before he can incorporate them in a production engine.

Senator MALONE. But he is prepared to do that, is he not?

General METZGER. He is prepared to do it if the material is furnished him in proper quality.

Senator MALONE. That is what is holding him back, is it not?

COST DIFFERENTIAL

General METZGER. That, and the cost of incorporating, the increased cost of his engine by incorporating those parts.

Senator MALONE. Let us get into the cost. You are not going to hold back on the cost where it is necessary for increased speed or range, are you?

General METZGER. That is correct, we will not hold back, but as I mentioned a few moments ago, the cost differential between steel and titanium is so great that it requires a very careful analysis of the military advantage.

Senator MALONE. It is the military advantage that we are talking about, is it not?

General METZGER. Yes, sir.

Senator MALONE. Did you not testify and did not Don Douglas and Bob Gross testify that to reach this maximum safe speed of 800 or 900 miles an hour and these long-range bombers, you had to have titanium?

General METZGER. There is no other suitable material or as favorable a material, strength-weight ratio-wise today.

Senator MALONE. Then we had testimony here from various military strategists that, instead of having 2 or 3 of the bombers that we are talking about which could do that, we may need 2,000 or 3,000 of them. That would take a good deal of titanium, would it not?

General METZGER. It would take a lot of it, yes, sir.

Senator MALONE. Do you agree with that estimate, or approximately so? You need a lot of them. You do not need just a half dozen or 20 or 30. Do you agree with that?

General METZGER. I certainly do.

Senator MALONE. Hasn't the DuPont Co. recently reduced the cost of some of its material?

General METZGER. They have reduced the cost of sponge, but the cost of sponge is a very small fraction of the cost of the wrought products.

EXPECT REDUCTION

Senator MALONE. What do you think about the cost? I think you and I have discussed this before. If we take the wraps off and start making titanium, and if the Government in these contracts takes the brunt of the obsolete equipment, which I think it can well afford to do considering that the saving in the cost of the material would override it in a very few months, do you yourself have any doubt that this cost will begin to be steadily reduced?

General METZGER. I have no doubt that it will be steadily reduced.

Senator MALONE. Does anyone else that you know of, who has the necessary technical information and status to judge it?

General METZGER. I believe everyone agrees that it will be reduced. The speed of the reduction and the magnitude of the reduction are debatable.

Senator MALONE. Do you not have to create the demand before you get the reduction?

General METZGER. Not only create the demand, but make available the supply.

Senator MALONE. You have to create the demand for the material. But if you told these producers who have these laboratories and who are spending Government money along with their own, and some of them only their own money, that it is just possible that maybe we do not need it as badly as we thought, and allow these rumors to go around the street and accumulate, is it not just possible that they would not be spending quite so much money or putting so many technicians on the job, whom they need elsewhere?

General METZGER. It could well set back the development within the industry itself, that is right.

Senator MALONE. We had testimony in this committee which is very disturbing. You know about some of it. I have mentioned one part of it today. I myself am fully convinced that there are very few people in this Government who are trying to do us harm, but there are a few. Whether it is through ignorance or whether it is through desire, like the Harry Dexter White aid memorandum to Morgenthau, Morgenthau's letter to the President, and the President's release to the public and the subsequent actions, whether it is through ignorance—let us give them the best of it—or desire, it was harmful, was it not? We find ourselves now, 10 or 15 years later, dependent on offshore areas for things we can't fight without, moving from a civilian economy to a war economy.

FEAR OF UNEMPLOYMENT

I am not going to ask you this question, but I may sometime. A lot of this material we are turning out and shipping to Europe will go in a warehouse and never come out, obsolete when it hits the ground—the stuff we have in the mill right now. Why? We are afraid of unemployment. We have miners on the street, we have the crockery people on the street, we have the textile people on the street, and we are putting more there every day. So, we move from a civilian economy, where we should be, to a military economy and are afraid to quit making appropriations for fear of unemployment.

At the same time, right under our noses we have two of the greatest civilian industries in the world right in front of us. One of them is titanium. I am convinced, not from my own estimate but that of people who know, that you can have a 5 to 10 billion dollar industry there in due time. I do not know how fast it will be. I refer to a civilian industry.

I am also convinced—and I had something to do with it, maybe oversold it, although I was not the only one trying to sell it—that the civilian application of nuclear energy will become one of the greatest industries in this country in the civilian production of power.

For 4 years I worked to get a little plant out in the West somewhere for 15,000 or 20,000 or 30,000 kilowatts of power, because it was costing 2 or 3 cents a kilowatt-hour, not 2 or 3 mills. I oversold it, or somebody did, and they are going to build 60,000 kilowatts, which is too big for the intermountain country mines that I had in mind.

I don't think there is anything classified about the fact that the Army is trying to build one to fit on a flatcar. Instead of building a 50- or 100-mile transmission line, run a flatcar out there, like a diesel plant or a Delco plant. It will work, too. I happen to know very well the admiral down here—maybe I had something to do with his being made an Admiral—and I went up to see him launch that submarine, the first thing they are going to drive by this power.

This is in its infancy, and it is going to grow fast. These are two industries that will bring this country out of any slump. What are we waiting for? They are not waiting now. They were for a while.

I would just like to pin this down, and I think we have today. At the present price of titanium, $15 a pound, and maybe $20 a pound for shapes, the chemical industry say they want it, and the milling industry say they want it. I am sure that, if we pulled in 10 or 15 or 20 other industries, they would say that they want it at the price now prevailing. If that is true, how are you going to get too much titanium? Do you think we can?

CONFIDENCE IN FUTURE

General METZGER. I have great confidence, as have you, Senator Malone, in the future of the titanium industry. When you ask the question, do I feel we can get too much, I would prefer to answer in this manner: We might get too much at a time, but I do not believe that the techniques of producing and manufacturing titanium will permit us to get too much at the wrong time.

Senator MALONE. In other words, the very constructive suggestion made this morning by Dr. Flemming takes care of that temporary situation, does it not?

General METZGER. Yes, sir.

Senator MALONE. I am going to ask you this, and then I think we will have completed our record for today, unless someone has something else to offer.

Only yesterday Secretary of State Dulles came before this committee, and I want to say that he was very helpful and cooperative. He appeared in executive session, and naturally the things he said could not be quoted. We wanted to know how politically stable some of these sources were where we had become dependent for things we cannot fight without.

The things I found out did not reassure me very much. That is as far as I can go on that business.

The same Secretary of State has said several times lately that in case, in Indochina or any other place—whether I agree with what he is doing has nothing to do with it. He is the boss in international policy. At least the President and the executive department is the boss. I may argue with you as to who is the boss in the regulation of the domestic economy that we have transferred to him every 3 years, expiring June 12, this time. I think it ought to come back to Congress, because the Constitution separates the regulation of the na-

tional economy and the foreign policy. We have now tied them together, I think in violation of the Constitution of the United States. I am simply referring to the Trade Agreements Act passed in 1934, and extended every time for 3 years until in 1950 it was extended for 2 years, and the last time for 1 year. Congress must decide whether they will still tie the domestic economy regulation to the foreign policy.

The Constitution, in article I, section 8, says specifically, and it does not stutter, that the legislative branch shall regulate foreign commerce and foreign trade, and it shall set the duties, imposts and excises, which we call tariffs and import fees. It does not say the Executive shall do it. It does not say that we shall change the Constitution of the United States by legislative act, either.

If we can do that, we could pass an act taking all the duties of the President and putting them in the President of the Senate, and pass it over his veto and leave him sitting there. I do not think it would stand up. It may be tested in the not very distant future.

The same Secretary of State says right now that we will have immediate retaliation. What does he need for this immediate retaliation 10,000 miles away? Does he need a fast airplane going 700 or 800 miles an hour, which will stand up and go 6,000 or 7,000 miles and come back; or does he need a B–27 or some of these planes that we have been using in World War II and in world war III, as I call Korea? What would you think?

General METZGER. I would take the airplane, myself, the faster the better, the longest possible range that we can acquire.

Senator MALONE. How can you build it until you get material of this kind, and increase the speed and increase the range beyond what you now have, except by better material and lighter material and stronger material and heat-resistant material? How can you do it?

TITANIUM QUALIFIED

General METZGER. Titanium possesses the qualifications of doing it better than any other material that we know at this time.

Senator MALONE. That is the way titanium might figure into the Secretary of State's statement, is it not?

General METZGER. Yes.

Senator MALONE. He does not have it now. Do you think it might make it easier for him to do what he said he was going to do if he had titanium in his planes?

General METZGER. Without question.

Senator MALONE. How does titanium figure in the thing? How would you do it? Would you use it for the plane covering, in the engines, and in the frame?

General METZGER. It would be used in both engines and airframes, structural parts and surfaces of the airframes, and, of course, structural parts of the engine. Certain equipments within the combat aircraft would be built of titanium.

Senator MALONE. Suppose Russia, with her 245 or 247 technical articles it has written on it, and the German engineers and scientists that they took over after World War II—suppose they have titanium in some volume, and we run into planes that would outfly us in this sudden retaliatory onslaught, what might happen?

General METZGER. It would be very serious, I am sure.

Senator MALONE. If we had a second-best Air Corps or a poker hand which was second best, is that about right?

General METZGER. That could very well be.

Senator MALONE. That is what makes this thing a must, is it not? Is that not the reason Don Douglas and Bob Gross sat there in all seriousness and took time away from their business to tell us it is a must? Is that not one of the reasons?

General METZGER. That is correct.

Senator MALONE. Is that not the reason that Mr. Hurley is willing to come down here to try to get something with which he can make a better and lighter and faster engine?

General METZGER. I am sure of it.

FOR CIVILIAN PLANES

Senator MALONE. When you come to this matter of cost, the testimony of the men who make the planes is that at the present cost they want it in civilian planes. Do you remember that?

General METZGER. Yes, sir.

Senator MALONE. They wanted it in the DC–7, and they could not get it. I forget what they said they could pay for a pound of titanium—I think it was something like $87 a pound—if they could get it, and still make money in a private plane carrying passengers and mail; is that not about right?

General METZGER. Yes, sir, in certain applications, that is correct.

Senator MALONE. Did they not say they could use all of it they could get in private planes if it were made available? I do not want to misquote Douglas or Gross. I do not know that they said they could use all they could get, but that they could use a tremendous amount of it at the present cost; that there was no drawback.

General METZGER. Yes, sir, at the present cost, if the material were available in proper quality and in proper alloys.

I think, Mr. Chairman, the record will indicate that several of the manufacturers stated that the present applications in commercial aircraft and many of the applications in military aircraft, as of the date of that hearing, were in the so-called commercially pure titanium, and that the future for titanium in military aircraft or, to a certain extent, in commercial aircraft, depended largely upon improved alloys and a reduction in price.

Senator MALONE. I did not understand they said reduction in price. They did say improved alloys. Did they not also say that if available, they were sure that the alloys would be developed?

General METZGER. I think we all feel that way. They agree, and I certainly do, too.

Senator MALONE. They said, I am confident, that the price was no drawback to civilian plane use.

General METZGER. Perhaps so. I do not know how strongly that was touched upon.

Senator MALONE. I am not sure about the $87, but they figured that there was a tremendous amount that they could pay per pound, and pay for it during the life of the plane.

COST VERSUS ADVANTAGE

General METZGER. The main reason, Senator Malone, that I bring up the question of price, is to indicate that in every instance where we permit an increase in cost of our aircraft or our engines, it must clearly indicate that the advantage gained is worth the cost, and that we can well recognize how certain applications resulting in certain weight saving wherein the present cost is supportable.

There is no question that we should support it. But as we go down into other applications where the gain is smaller, then the cost factor becomes more important and might rule out the advantage.

Senator MALONE. But any gain you can make in a military plane and a long-range bomber that increases the range or the speed, you can pay the price for it?

General METZGER. If the increase in the speed or the increase in the range is substantial, yes, sir, we can.

Senator MALONE. You are not going to put these boys up in a second-rate plane, not if the people of this country find it out, because you think the price is a little high, and wait until they get it into civilian use and then we will take it in planes? These boys belong at home. They do not belong up in the air in the first place, but they are willing to go if they have as good a plane as the other fellow. There is plenty of evidence that they did not have it in Korea. Do you want that to happen the next time?

NEED BEST AIR FORCE

General METZGER. Most certainly not. I think we all recognize that we must have the best aircraft that we can possibly build and use in our air arm.

Senator MALONE. Was there not a little reluctance of boys to go into the Air Corps for a while because of the situation out there?

General METZGER. It was reported that there was some reluctance.

Senator MALONE. I talked to some of them, and I think I can tell you that there was quite a little reluctance, because up to that time America had always furnished the best equipment on the battlefield, and you knew if you did not have it the other fellow did not have it either. That is quite a little assurance when you are out there by yourself or with just a few people who are going to have to hold something.

When we get in Washington and get on these soft cushions and start talking about a dollar or two a pound, but let them fly a little slower, they do not like it, and I don't either.

General METZGER. Mr. Chairman, the study furnished by Curtiss-Wright for the record covers very ably this cost problem. Perhaps the chairman, after review of it, would care to discuss that further. I am sure that it merits discussion. I would be most willing to appear and discuss that at any time the Chair would see fit.

Senator MALONE. I would like very much to discuss it further. We have information from Mr. Hurley, and I shall call him back temporarily here, that with the needs right now—and, of course, we are developing better alloys all the time—he is prepared to go into this

construction, part by part, as approved by you or anyone in charge, and allocated the proper amount of material, just so he knows he will get that material and will not have to drop back and change his plane.

General METZGER. That is true, Senator Malone, and we propose to recommend immediately that approval be given to 4 or 5 of the parts listed in Mr. Hurley's study.

I believe Mr. Hurley himself would not recommend that we approve all of the parts which possibly could be produced with titanium today. However, perhaps he would care to testify to that.

Senator MALONE. General, you could make the entire plane out of titanium, but it would be a waste of money.

General METZGER. Surely.

Senator MALONE. But we are talking about engine parts where it is needed for its heat-resistant properties and for its lightness of weight and its strength. As far as that goes, you agree it should go in both the frame and the engine?

General METZGER. Yes, sir.

Senator MALONE. That is the kind of use that, both in the military aircraft and in the civilian use, would be much more according to the testimony of the planemakers. They made you look conservative at the time, saying it would amount to even more than 150,000 tons a year. Is that not what they said?

General METZGER. Under mobilization conditions at the same rate of production as in World War II, and the same peaks, that is right, they did.

Senator MALONE. They said then it might go up to 700,000 or 800,000 tons, do you remember that testimony, if they demanded the number of planes to be manufactured today per month and per year as they did in World War II; that it might go to 700,000 or 800,000 tons. Do you remember that?

General METZGER. That is right. Using 20 to 40 percent weight in titanium.

Senator MALONE. That is right.

They further testified that a pound saved in the frame, and knowing it ahead of time—which you never know—could amount to about a 10-pound saving in the whole plane.

General METZGER. A pound saved in the deadweight, such as in the engine or equipment, known in advance to permit design of the airframe itself, could result in 6, 8, or 10 pounds, depending upon the type of aircraft.

Senator MALONE. Because you did not need the wingspread, you did not need the power for the same speed, if you knew what your weight was going to be. But you have never been in a position to know that, because you did not have the titanium.

General METZGER. That is certainly correct.

Senator MALONE. Now we are back to where we started. What are we waiting for? Are we waiting for cost? No, I would not think you would say that now. Are we?

General METZGER. No, we are not waiting for cost at this point.

WAITING FOR TITANIUM

Senator MALONE. We are waiting for titanium.

General METZGER. That is correct, sir.

Senator MALONE. In other words, then, if the Secretary of State happened to get his hand called on this business, he would not be too well off at the moment; but if we had this titanium in 3 or 4 years, we would be right on top of the heap, is that about right?

General METZGER. Yes, sir; I think so.

Senator MALONE. General, we certainly appreciate your coming here again. You are always so good to this committee to give us the benefit of your knowledge, which is the greatest of any single person that I know of on the overall picture.

Mr. Hurley, would you take the chair for a couple of minutes again, please?

FURTHER STATEMENT OF ROY T. HURLEY, CHAIRMAN OF THE BOARD, CURTISS-WRIGHT CORP.

Senator MALONE. Mr. Hurley, you have heard the testimony so far here. You were kind enough to submit these documents which have been accepted as exhibits for the use of the committee. They will be treated any way you see fit to tell us to treat them. Some of it may be published if it is all right with you and will not jeopardize the security of the country.

The matter of cost has been injected. The committee chairman has been under the impression that an amount of titanium away beyond what is available, up to 150,000 tons a year, perhaps, could be utilized by the military aircraft and the civilian aircraft at the present price if known to be available so that the frame design, the wing design—which is included, of course, in the frame—and the engine design could be started off knowing that titanium is going to be available just the same as the steel and aluminum.

I would like to have you clarify that situation for the committee.

CANNOT LOOK BACK

Mr. HURLEY. Senator, I am at an advantage in this situation, I would say, because I am a manufacturing man. I started in the shop. I spent my entire life making things.

Our job is to convert the titanium into usable engines. We do not dare put titanium in engines unless we put it in to stay, because if we were to put it into an engine and then we suddenly had to take it out of the engine, the airplane that General Metzger would buy would not perform well enough for him to use it. So we could not go back, regardless of cost.

Once we go in, we have to stay in, or we have to go back to the Model T Ford, if you will.

Senator MALONE. Whatever model you have.

Mr. HURLEY. Once we go to titanium, we stay with it, and we cannot go back. Cost has nothing to do with that.

The cost of the sponge to me today is relatively unimportant. The cost of the preparing of the mill products is comparatively unimportant. The high cost that is in the minds of people today is that of converting the mill product to the engine part.

We could not go ahead and put a piece into an engine part that cost too much, because our requirements for machine tools and labor would

be too high. Regardless of the cost of the titanium, it would not be the thing to do.

Senator MALONE. You would use more in labor and changing over?

Mr. HURLEY. I am personally convinced that every piece we picture here, plus many, many more, can be made of titanium if we just start. I think that is the thing that we need.

These gentlemen are up against it, apparently awaiting the mobilization plan. I came to Washington in 1948. The Secretary of Defense then was Mr. Forrestal, and at that time we were waiting for mobilization requirements.

MUST GO FORWARD

I do not think we will ever have them. I think we are working in a vacuum when we wait for those things. It is my complete recommendation, sir, that we start and we go ahead.

My program has been limited only by my ability to use the men in the organization and the equipment we have. A bigger program is possible. A bigger program is entirely practical if we can just coordinate these things and get under way and get going.

As I said, I have an advantage because I am the guy who has to make the piece, and the other gentlemen are the men who have to do the planning. So they have to depend on my coming through.

I know they have some reluctance to talk about prices and things, because the minute you let the public get the idea that you are not interested in price, then a lot of people take advantage of the situation. It is a duty for them to see that the price is right. They are spending the taxpayer's money.

I feel it is a duty for us not only to save money, but if we go into things that are too damned expensive we will not be able to make them during the war, because expense comes through waste of machines or manpower or something else.

We have a big industry here, and I feel we should get under way with it and get going.

I also have an advantage, Senator, that that gray book is packed with information on the machining of titanium and its alloys, and that information generally has not been made available. It has just come off the press. We are going to distribute it throughout the industry. I believe that will open the door many, many places.

Senator MALONE. Do you have any doubt—of course, you have to go to the man who is doing it, at least I do, to get authentic information—if the titanium were available of the proper hardness, the proper quality of titanium, raw material, do you have any doubt that the proper alloys would be developed for each particular use in a very reasonable period of time?

ALLOYS TO IMPROVE

Mr. HURLEY. This plan is based on what is available to us. We know now of alloys that are superior to these, and we know they will be available shortly. We are sure of that, Senator.

Senator MALONE. Do you think there will be a continual improvement in the alloys that can be put to use, and perform even greater service than those you have included in your plans?

Mr. HURLEY. Senator, there is no question about that, because if it doesn't take place, we are going to stop learning and increasing our know-how, and I cannot foresee any limitation on our ability to learn and do things and know more about the material and the product.

Senator MALONE. Whether it is aluminum or any other scarce material or plentiful material, whenever you had a use for any material and needed it badly enough to spend the money to develop an alloy, it was generally developed, was it not?

Mr. HURLEY. That is right.

Senator, you referred to aluminum. Let's look at World War II. We expanded for aluminum then. There were people who thought we had too much capacity for aluminum, but by the time the Korean episode came along, the farmers were using it for the roofs of their barns, and so forth, and our civilian economy came to depend upon this overexpansion to the point that it was no longer available for war, and we had to expand again.

It seems to me I read in the paper last Sunday that we were again expanding our aluminum production.

So all these people through the years who said we were going too far, that we were spending too much——

Senator MALONE. And the more of it you make, the cheaper it gets.

Mr. HURLEY. That is right.

Dr. FLEMMING. Mr. Chairman, might I comment on one of the comments that has just been made?

We arrive at the same end result, namely, the desirability of moving on this titanium. There isn't any question in my mind about it at all. But I would like to say that I am not quite as pessimistic on the question of the Department of Defense providing us with mobilization requirements. I appreciate the past history on that, but for the first time in the history of mobilization planning, Secretary Wilson and Deputy Secretary Kyes have provided us with requirements information on a thousand major military end items. They would account for 80 percent of the cost or 80 percent of the expenditures for military hard goods in the event of all-out mobilization.

That in turn is now being translated into materials requirements.

NO HESITATION

I am not saying that, if we got that, that would be the last word, because we all appreciate the fact that strategic plans change, and then the requirements change and you have to go back and go over the whole process again. You just cannot stop and wait while all those processes are going on. I am in complete agreement on that. But I do want to indicate that I think that under the direction of Secretary Wilson and Deputy Secretary Kyes, we are making more progress in the direction of being provided with reasonably firm information as to what our requirements would be in the event of all-out mobilization than ever before in the history of the Nation.

I am sure that on a scale of 100, they would not say it is at 100 if they were rating it. They might rate it about halfway up the scale of 100. But it is a lot better than being at zero.

We are making progress, I think, in that direction, and I think we will make still more progress. My attitude has been that while we are

figuring requirements, we do not stop working toward expansion goals, I don't care what area it is. We do not stop working toward stockpile objectives. We take our existing goals and our existing objectives, and we drive toward them, and then when we get new information or better evidence, we make the adjustments and continue to go ahead.

Senator MALONE. I think it is evident from your attitude that it has changed, because there was not any use for anyone to say they knew all about any of this material. When the contracts were first let 3½ years ago, there was very little information available.

Therefore, no one blames the GSA for having a hardness that does not fit the present specifications.

Dr. FLEMMING. That is right.

Senator MALONE. But we are looking ahead and not back.

Dr. FLEMMING. That is right.

Senator MALONE. The Department of Defense sent down to you or to your committee a demand or recommendation for 35,000—just using rough estimates—35,000 tons a year. Your committee, or someone down there, cut that to 22,000, and later raised it to 25,000, and I think it has been raised maybe to 35,000.

But you did not at that time believe you had information enough to allow them an objective of 35,000 tons a year.

Dr. FLEMMING. At that particular time.

Senator MALONE. Up to the 35,000 or the 32,000.

It perturbed this committee greatly that no one apparently was getting into the basis of the thing to show, and also information enough for the public. You said you were going to use a material costing $15 a pound. It does look like a lot of money, but when you save $10 of something else, maybe it is not so expensive. Especially when you save the gasoline and you save a few lives by it, it becomes unimportant.

Being up to this point, I just wanted to establish if there was any hesitancy, and you have said there was not, about going right ahead to the estimated need for the industry, both the war industry and the civilian industry, and use the stockpile to take up the slack until men like Mr. Hurley could have confidence in the orders from the General, or whoever is in his position, allocating it to him, and confidence that he could keep it in his engine.

That is what Douglas and Gross said about the frames. I would have to read their testimony again to be entirely familiar with it, but I was so impressed with their knowledge and their desire that it was a must material.

That is what you have said, Mr. Hurley.

PRODUCTION SAVES MONEY

Mr. HURLEY. Senator, I do not disagree with the gentleman. The missing element, to me, is the putting of it in production. When you put it in production the costs will go down.

Dr. FLEMING. That is right.

Mr. HURLEY. All of the talk and everything else is wasted and academic if we do not put it in production.

Dr. FLEMING. Mr. Hurley and I are in complete agreement there. I mean I feel, as you have indicated, that we have an obligation to make sure of the fact that the people who are supplying it for the

Government are supplying it at the lowest possible cost under present conditions and circumstances.

I am sure that Mr. Mansure and his people will make sure of that fact.

But, having made sure of that fact, then in the light of the evidence that we have, I do not think that the cost should be a factor in our thinking, because, as I understand it, the intent of the Congress in providing us with a two-billion-one-hundred-million-dollar revolving fund under the Defense Production Act is to put the Government in a position where it can move in and break this kind of vicious circle and get the production going. That is the reason for it.

Senator MALONE. Naturally you all agree, I am sure, and I agree and everyone I have discussed it with agrees, that it will be like any other material: If it was not for our preparation for war right now, it might be 25 years before it would go into general use, because it would not be necessary or sufficiently necessary to get it.

But if we mean what we say—and if we don't, we had better quit talking about it—getting ready to whip somebody in case they attack us, or getting ready to drive them out of a place five or six thousand miles or ten thousand miles away, it is not a question of whether I agree with that or not. I do not run that part of it. If they say they are going to do it, they had better not take these American boys in there again and not have the best airplanes there is in the world.

Dr. FLEMING. Mr. Chairman, I can say this, and say it advisedly: In my judgment, there has to be a real sense of urgency relative to all aspects of our defense mobilization program.

Senator MALONE. I agree with that.

Mr. Hurley, we certainly appreciate having you here. Dr. Flemming, we have taken up your whole forenoon again. We appreciate your presence.

The committee will be in recess subject to the call of the Chair, and again I say we are very appreciative of your appearance.

(Whereupon, at 1:30 p. m., the hearing was adjourned.)

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